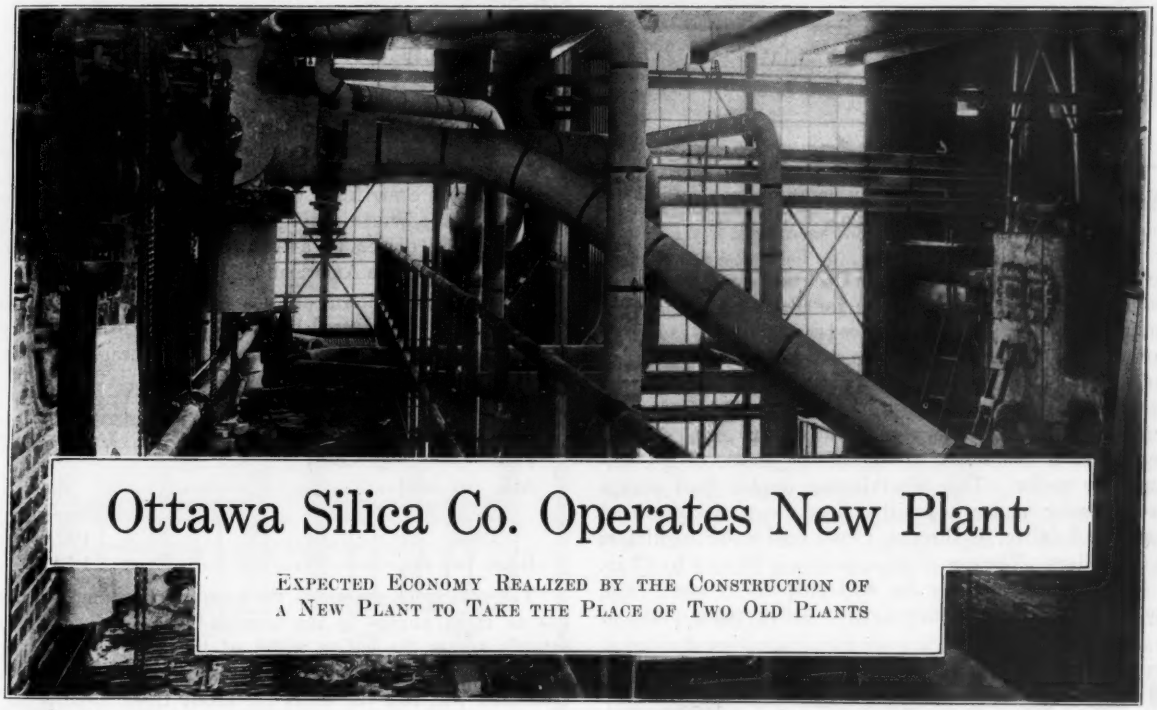
POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

VOL. XXVIII CHICAGO, FEBRUARY 15, 1924 No. 4



Ottawa Silica Co. Operates New Plant

EXPECTED ECONOMY REALIZED BY THE CONSTRUCTION OF A NEW PLANT TO TAKE THE PLACE OF TWO OLD PLANTS

REDUCTION OF THE cost of producing power and improvement in the reliability of service are the chief considerations which influence a change in power generating equipment and methods. New machinery is installed because it will reduce the present unit costs, which are based on the physical condition and adaptability of the old station equipment. It was a careful consideration of all the factors involved which led the Ottawa Silica Co., of Ottawa, Ill., to throw into the discard two old boiler houses and erect a new central steam-generating plant which supplies the steam for two sand preparing mills and two sand pits. Each sand pit is served by a separate mill in which the sand is washed, dried, screened or graded and loaded for shipment. The new boiler house is located just east of the east mill and on the old Illinois and Michigan barge canal.

Feed water is normally taken from the canal and passed through a Dodge Manufacturing Co.'s softener. An average analysis of the raw water is shown in the accompanying table.

Treated water will average 4 deg. in hardness and 2.50 deg. alkalinity. The canal water flows by gravity to the suction connections of two Advance Pump and Compressor Co.'s steam-driven, direct-acting duplex pumps. Each pump is 7 by 4½ by 8 in. in size and is equipped with a Madison-Kipp lubricator.

Suction connections of these pumps are arranged so that raw feed water also may be drawn from the sand pits in case no water is in the canal. It is necessary to use booster pumps in the sand pits in order to get the water within the suction reach of the softener pumps. The softener pumps are controlled by Williams Gauge Co. governors.

ALL CONDENSATE IS RETURNED TO A RECEIVER

Raw water is delivered by the softener pumps to the mixing tank of the treating plant from which it passes to the settling and storage tank. Located directly over the boiler-feed pumps is a receiver into which all condensate is returned. A float valve in this receiver maintains a constant level by admitting make-up water from the treating plant. This make-up water flows to the receiver by gravity and enters the receiver through a special distributor manifold so that the return and make-up waters are well mixed.

This method eliminates the wastage of hot return water and makes use of only such treated water as is necessary to make up for the uncontrollable loss of condensed steam. Two pumps, one a steam-driven centrifugal and the other a direct-acting duplex, will draw the water from the

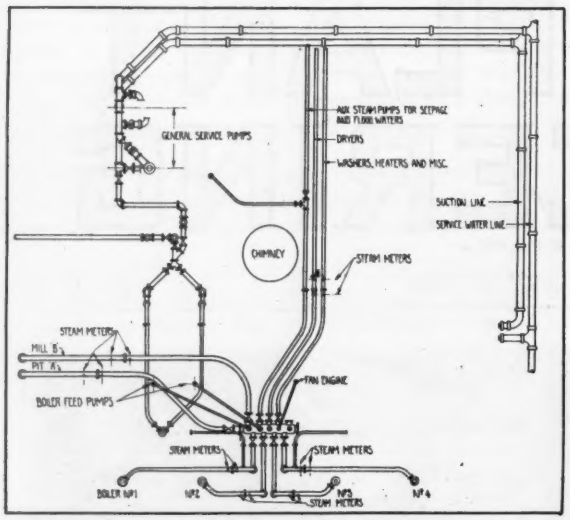


FIG. 1. STEAM FLOW METERS ARE PROVIDED FOR THE MAIN STEAM LEADS

receiver and discharge it into the Cochrane open feed-water heater. Exhaust steam available for heating feed water is obtained from the fan engine, feed-water pumps, softener pumps, air compressor, the steam-driven mill-service pump and the booster pumps which are located between the return receiver and the feed-water heater. The feed-water temperature averages between 200 and 210 deg. F. All feed water is metered at the heater by means of a Cochrane flow meter. Two Worthington duplex feed pumps receive water under a positive head from the overhead heater and deliver it through Copes feed-water regulators to the boilers. The size of these pumps is 10 by 6 by 12 in.

General service water for mill purposes is taken from the canal by means of either a direct-acting steam pump or a motor-driven centrifugal pump. The former was manufactured by the Worthington Pump and Machinery Corp. and the latter, driven by a General Electric Co.'s motor, was furnished by the American Well Works Co.

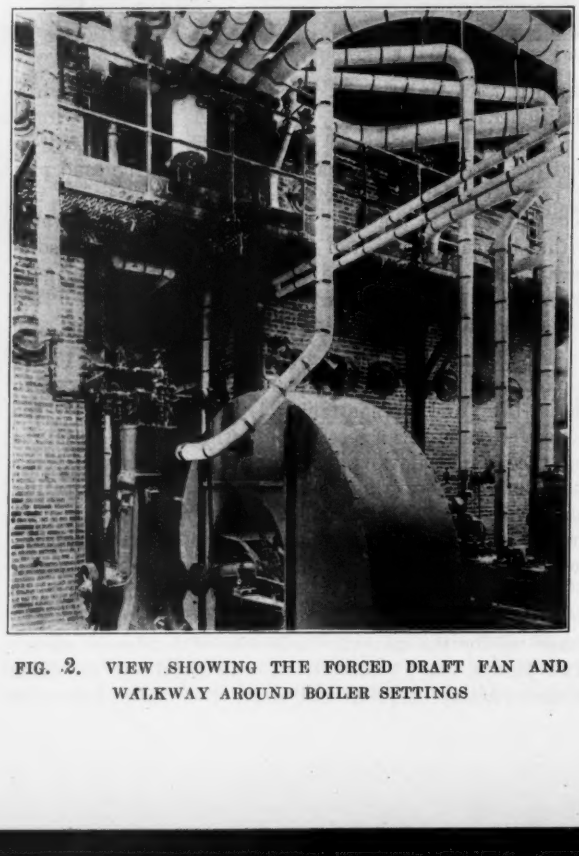


FIG. 2. VIEW SHOWING THE FORCED DRAFT FAN AND WALKWAY AROUND BOILER SETTINGS

AVERAGE ANALYSIS OF CANAL WATER

Incrusting solids:	
Calcium carbonate	7.89 gr. per U. S. gal.
Magnesium carbonate	1.10 gr. per U. S. gal.
Magnesium sulphate	3.12 gr. per U. S. gal.
Magnesium chloride	0.09 gr. per U. S. gal.
Iron and aluminum oxide	0.35 gr. per U. S. gal.
Organic matter	present
Silica	0.29 gr. per U. S. gal.
Suspended matter	2.05 gr. per U. S. gal.
Total gr. per U. S. gal.	14.98
Total lb. per 1000 gal.	2.14
Non-incrusting solids:	
Sodium chloride	2.99 gr. per U. S. gal.
All others	0.41 gr. per U. S. gal.
Total gr. per gal.	3.40
Total lb. per 1000 gal.	0.49
Total hardness	14.3 deg.

Illinois coal, known as Ziegler 2-in. screenings, is received by rail and stored by means of a Brown Hoisting Machinery Co.'s locomotive crane. An average analysis, dry basis, of this coal is as follows:

Moisture, per cent	7.35
Volatile matter, per cent	30.52
Fixed carbon, per cent	56.91
Ash, per cent	5.22
Total	100.00
B.t.u. per lb.	13,490

The coal track on which the locomotive crane operates lies at right angles to the overhead coal bunker which extends across the entire width of the boiler house. In normal times, about 4000 T. of coal is stored, this, it is estimated will run the mills for about three months and still leave an ample reserve for fire protection purposes. New shipments of coal may be stored or run to the boiler house and unloaded directly from the car to the firing aisle bunker by a single operation of the locomotive crane, which carries a bucket of ¾-yd. capacity. At present, the coal bunker is open to the weather. It is planned to cover this over in such a manner that one section may be uncovered at a time in order that the crane may still fill the bunker as at present.

Boiler equipment consists of four Stirling boilers, set in batteries of two each. Each boiler is rated at 312 hp. and is designed to operate under a pressure of 160-lb. gage. The boilers are not equipped with superheaters. The selection of boiler units was based on operating three boilers at 50 per cent above rating with the fourth unit held in reserve. These units are set on the same floor level as are the pumps.

COAL IS WEIGHED TO EACH STOKER HOPPER

Coal is stored in a Brown Hoisting Machinery Co.'s ferro-concrete bunker. A Brown weigh larry, with scales, travels beneath the bunker gates. Coal is weighed and then spouted to an extension hopper provided at each stoker. Each boiler is equipped with a Combustion Engineering Corp. Type E stoker, the grate surface of each

stoker being 56 sq. ft. Each boiler is also equipped with a Bailey steam flow meter, five units of Diamond valve-in-head soot blowers, a 5-in. Crane non-return valve, and Cadman blowoff valves. The blowoff line from each boiler is separate and discharges to the atmosphere out over the sand pit. Each pipe being separate affords a simple method to check up any blowoff valve leaks.

Forced draft, at a pressure of about 3 in. of water is furnished to the stokers by a plate fan to which is direct connected a 7 by 7-in. vertical steam engine. This unit

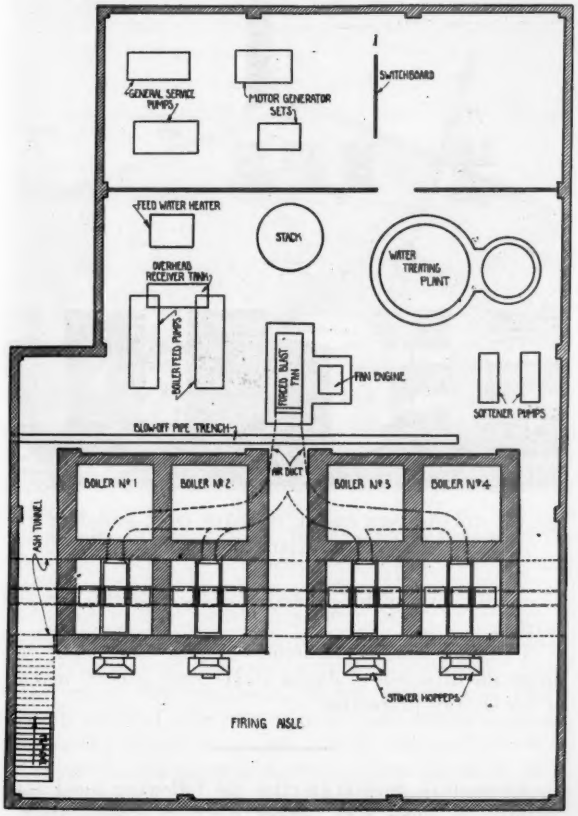


FIG. 3. GENERAL PLAN OF THE NEW PLANT

was furnished by the Clarage Fan Co. The air duct leading to the stokers runs beneath the floor and is made of concrete. The fan engine is equipped with a Madison-Kipp lubricator.

Load control of each boiler is taken care of by an Ajax regulator as made by the National Regulator Co., and a Fessendon-Ellis damper regulator. The Ajax regulator controls the stoker and fan speeds in accordance with the variation in steam pressure. A small locomotive type Westinghouse air compressor has been provided as a necessary adjunct to the Fessendon-Ellis damper regulators. The action of this control system is as follows: A decrease in steam pressure will cause the stokers and fan to speed up. The resulting increased pressure under the grates tends to increase the pressure over the fire which causes the damper regulator to open the damper.

Each boiler setting discharges its waste gas into a common breeching which leads to a steel self-supporting stack which is 7 ft. inside diameter by 150 ft. high. The setting walls are as yet un-insulated; they will, however, be insulated in the near future. The stack is unlined for the

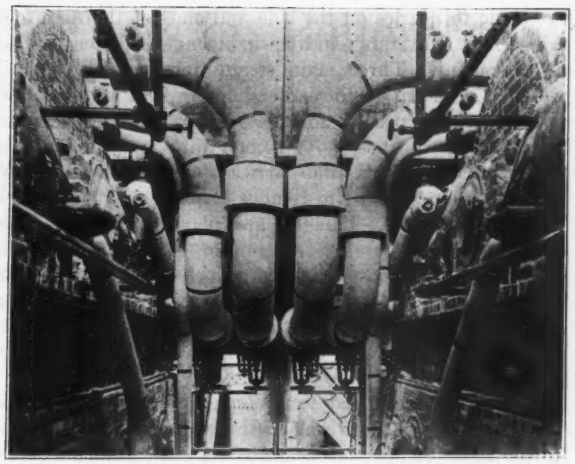


FIG. 4. BOILER STEAM LEADS DISCHARGE INTO A MANIFOLD

reason that it has not been found practicable to line stacks which are located near the sand pits where a great amount of blasting is carried on.

Ash Hoppers Are Constructed of Concrete

Extending the entire width of the boiler house is a concrete ash tunnel. The boiler setting ash hoppers are constructed of reinforced concrete and lined with brick. Three discharge gates are placed under each stoker. These discharge into a small ash car which is run out on a track to the edge of the sand pit and dumped. There is no costly ash disposal system involved in the operation of this plant.

Steam piping for this plant is interesting in that the lead from each boiler discharges into a short manifold which is located just at the rear of the boilers and opposite the center aisle. A Crane gate valve has been placed in each boiler lead at the manifold. The steam for auxiliaries is taken from five connections made in the top of the manifold and the main steam connections for the mill service

FIG. 5. COAL IS DISTRIBUTED TO THE STOKERS BY A WEIGH LARRY

are made to nozzles on the side and ends of the manifold. A receiver and trap remove what condensate may collect at this point. Three main steam lines run to the mill which is adjacent to the boiler house. One of these lines is used in mill process for the sand washers, heaters and miscellaneous purposes. A second line supplies the sand driers and the third line carries steam to the auxiliary pumps which are used to remove seepage and flood waters from the sand pits. This line also plays an important part should there be an interruption of electrical energy by means of which most of the pit work is performed. Republic steam flow meters are installed on the first two of these lines.

Outdoor Steam Lines Are 1800 Ft. Long

Two leads equipped with Republic steam flow meters pass through the south wall of the boiler house, drop down to the sand pit floor level, and run for a distance of about

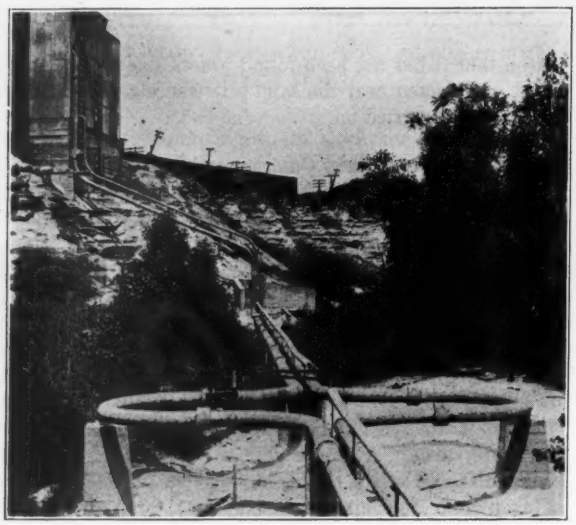


FIG. 6. LONG STEAM LINES ARE PROVIDED WITH LONG RADIUS BENDS

1800 ft. to the south pit and the other mill. All steam piping is of standard weight, with ferro-steel screwed flanges. The joints are made up with Cranite gaskets. All pipe covering was made by the Armstrong Cork and Insulation Co. and it is applied 2 in. thick on all high pressure lines and 1 in. thick on low pressure steam and hot water lines. Inside the boiler plant the pipe covering is jacketed with a single layer of canvas held in place by bands. The insulation on the outside lines is protected by a single layer of ⅛-in. thick roofing paper which is held in place by means of copper staples and wire bands. On the long radius bends wire is wound spirally outside of the paper.

Foundations for the building are of concrete and the building proper consists of a steel frame covered with corrugated zinc. Ventilated steel sash covers a good part of the building walls. Runways of open grating extend around the feed-water heater and the boiler settings.

Three men are required to operate the plant during the day turn. One man acts as fireman, another as engineer and the third is listed as a crane man, whose duty is to care for the coal supply both in the yard and to the boilers and ash disposal. Sufficient coal is put in the overhead bunker during the day run so that but two men, a fireman and an engineer, are required on the night turn.

All electrical energy used by the Ottawa Silica Co. is purchased under contract from the Illinois Light & Power Corp. The incoming current is stepped down from 33,000 v., 60 cycle, 3 phase to 440 v., 60 cycle, 3 phase. Practically all mill motors are operated at 440 v. The exceptions are, certain direct-current crane motors which are operated by 220-v., d. c. obtained through a motor-generator set and several special application of 110 v. at 30 and

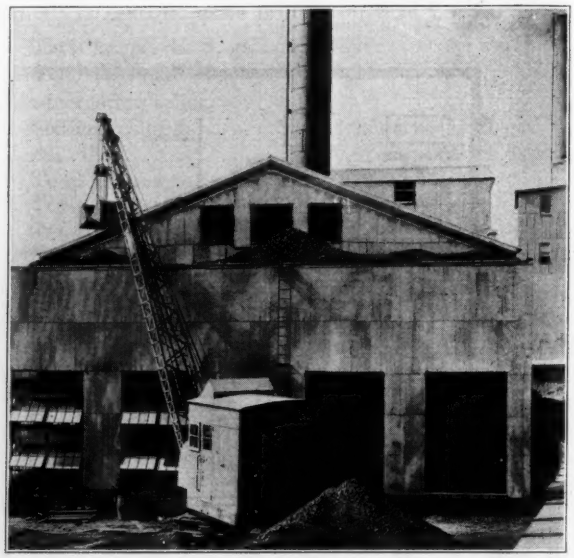


FIG. 7. LOCOMOTIVE CRANE UNLOADS COAL DIRECTLY INTO FIRING AISLE BUNKER

15 cycles. Two motor-generator sets supply this low-cycle current.

Planning and construction of this new plant were under the direction of James B. Herring, general manager of the Ottawa properties.

Edward G. Sheibley cites the following incidents in warning to those who neglect common consideration of safety principles:

"Carelessness accounts for many accidents. A helper holding a chisel while a fellow workman was sledging was struck on the hand by the sledge when the workman missed the chisel. A workman rolling a cam on the floor brushed an emery wheel and was injured. A workman passing through a mill stepped onto a piece of scrap left in a passageway and the end flew up and struck him in the face. Several workmen were breaking up wooden cupboards, and left boards with protruding nails lying on the floor. A helper stepped on one of the boards and a nail pierced his foot. An oiler, with oil on his hands, went to a fire to light a hand torch but instead of lighting the torch the oil on the man's hands ignited and a serious burn resulted. The new employee needs to be instructed in careful conduct in every operation in which he takes a part.

"To be careful means the concentration of attention on the matter in hand. There is always the inclination to relax individual vigilance and misfortune is the price very often paid for a moment's thoughtlessness. Many are lucky and "get by" but a large percentage of careless men sooner or later pay the penalty for their negligence."

Hydrostatic Pressure Tests on Boilers

MANY DEFECTS IN BOILER ARE NOT REVEALED BY HYDROSTATIC TEST; INSPECTOR MUST DEPEND ON VISUAL EXAMINATIONS AND HAMMER TEST. BY W. H. FITTUS*

CONSIDERABLE misconception apparently exists as to the merits and purpose of an hydrostatic test as applied in accordance with standard practice, to boilers of stand construction. It is the purpose of this article to give an outline of the writer's ideas on the principles involved.

It is the general purpose of the test to detect if possible, general weakness or defects not disclosed by visual examination and the hammer test.

GENERAL WEAKNESSES AND DEFECTS

A—Cracks following line of flanging and line of tube and rivet holes; cracks in body of plates and in cast-iron parts if any. Lap cracks; various fractures.
B—Faulty welds.
C—Burned or otherwise faulty rivets.
D—Broken stays.
E—Improperly stayed surfaces, including furnaces.
F—Thin flat surfaces.
G—Leaks.
H—Dents and bags.
I—Pitting and corrosion.

COMMENTS ON GENERAL WEAKNESSES AND DEFECTS

Owing to the care taken in the steel mills during the process of the manufacture of boiler metal, the possibility of cracks due to defective metal is reduced to a minimum so far as new boilers are concerned. To those not conversant with the A. S. M. E. Boiler Code, a perusal of the rules for chemical properties and analysis, physical qualities and physical tests should prove interesting.

Cracks in new boilers are more likely to be due to faulty workmanship than anything else. Punching holes in a crude manner, for tubes and rivet holes could easily cause cracks between holes closely spaced and cracks between edges of holes and edge of plate, where holes are too close to corners and edges. It is obvious that we do not expect to find many such cracks where the A. S. M. E. rules for spacing of holes, punching, reaming and drilling are observed. Such defects are more likely to be found in old boilers than in new.

Cracks in the body of plates are the exception rather than the rule. Such cracks are more likely to be due to faulty manufacture of the steel than to stresses set up during the manufacture of or the operation of boilers. Stresses are set up in boilers during the process of raising steam, where the water circulation or heat distribution is poor either generally or locally. In such boilers, mechanical means of circulation is often resorted to. These stresses, however, are more likely to affect the seams and flanges than they are to affect adversely, the body of the metal. The stresses are due to unequal expansion.

Fortunately the use to which cast iron may be put in modern boiler construction is greatly restricted. Its cracking qualities are sufficiently well known to render more than passing comment.

LAP SEAMS ARE SUBJECT TO LAP CRACKS

Surely we do not expect to find lap cracks in new boilers, however, there is no harm in looking for them. Lap cracks have been found in old boilers. The use of longitudinal lap seams is greatly restricted in modern practice, thus materially reducing the possibility of lap cracks. It is obvious that the radii of the curvature of the shell at inside and at outside lap differ by the thickness of boiler shell. The tendency of an internal pressure on an imperfect cylinder is to make the cylinder walls conform to a true circle. A lap seam shell is not truly cylindrical, therefore an internal pressure causes a bending tendency along lines near and parallel to the edges of seam laps.

In many instances, bending action does take place although not to a perceptible extent in every case. Naturally, the extent of the bending varies with internal pressure. This slight bending, over a period of years may cause crystallization and subsequently a lap crack.

Cracks at flanges are due to faulty workmanship, faulty material, or a combination of both these features. Flanges may crack when made with too small a radius, or formed when a steel is cold, "burning" of a flange will sometimes cause fractures.

Water pressure will not reveal every crack, because every crack or fracture does not leak, therefore the hydrostatic test should not be depended upon too much in this respect.

In modern practice the extent to which welding may be done on boilers is strictly limited. Except in low pressure work, one is almost safe in saying that welding is not permitted where it would be subject to a tensile stress, therefore, a hydrostatic test, generally speaking, will only show whether a weld is pressure tight or not.

It is now permissible to weld every seam of a low-pressure boiler, provided the required factor of safety is adhered to. A sufficiently high water pressure would rupture a sufficiently weak weld. It is much better to rupture a boiler with water pressure, than with steam pressure, because water is not appreciably reduced in volume by the application of ordinary pressures; it therefore will not expand appreciably if the pressure is reduced. If a vessel should rupture while under water pressure, the water would simply issue forth and do little if any harm. Very careful measurement would show a reduction in the volume of a body of water put under sufficient pressure, however, this reduction is thought to be due more to the compression of air or other gases dissolved in the water. This feature is not of sufficient moment to warrant further discussion. In passing, however, it is well to mention that air or other gas pockets should be avoided in vessels being put under a pressure test. If a sufficient body of air were confined in a boiler, there might be disastrous results, should the vessel rupture while under pressure.

THROW AWAY BURNED RIVETS

Sometimes rivets are "burned" and instead of being thrown away, are driven. "Burning" as the term implies, is caused by heating a rivet to a temperature whereat there is a rapid mixture of oxygen and steel; the product is iron oxide (steel really is iron with other elements added). Iron oxide is not so strong as steel. Burned rivet heads may drop off if their position is such that a stress is applied as a result of a test pressure. Rivets are sometimes driven up when they are too cold. In addition to not properly filling the rivet holes, these rivets are likely

*Inspector for The Travelers.

to be fractured in such a manner that the heads may drop off when a water pressure is applied but the hydrostatic test will not reveal all faulty rivets.

Items D, E, F, have much in common. If a sufficient number of stays on a given area are broken, or if a flat surface is sufficiently improperly stayed or if it is thinned sufficiently by corrosion or otherwise, such surfaces will bulge under pressure. An inspector detecting this bulging effect should then determine the primary cause. In the water legs of firebox boilers the source of the trouble may be due to broken stays. Stays having holes drilled in their ends, and hollow stays, may readily be detected when broken, as water will issue through the holes. It is therefore important that these holes should be kept clear and should be drilled deep enough so that they will extend beyond the inner surface of the stayed sheet.

Water pressure naturally will reveal leaks; it is therefore important that the water used should be free from solid matter that would temporarily stop small openings and thus defeat to some extent one purpose of the test. All surfaces should be accessible for inspection when possible in order that leaks and deformations due to pressure may be detected.

Keep Records of Furnace Diameters

Boiler pressure has a tendency to cause the collapse of circular furnaces. Before a total collapse, a furnace necessarily becomes somewhat oval. This collapsing tendency is therefore capable of detection if careful internal diameter measurements are taken before and after the test pressure is applied. The diameter measurements should be taken at various angles and positions. Records should be carefully kept and respective "pressure" and "no pressure" measurements compared. If there is a perceptible collapsing tendency, some of the diameters will show an increase and others will show a decrease.

I have no data available to show what is the maximum safe variation of diameters for various conditions. It is reasonable to believe that not many furnaces are sufficiently rigid to withstand a high pressure without becoming at least a little distorted.

Bags or bulges occur in parts of boilers subjected to furnace heat. The causes are well known to the engineering fraternity. So far as the usual bag on the fire sheet of a horizontal tubular boiler is concerned, the writer is not aware of any particular advantage derived from the use of the hydrostatic test, because in every case it is advisable to remove the bags by driving them back to the original curvature of the shell, or if they are exceedingly bad a new half sheet should be installed. A small bag does not materially reduce the strength of a boiler but loose scale and mud are likely to accumulate in it and cause further bulging. For this same reason as well as others, patches on the fire sheet should be avoided if possible.

The test as applied to bulges in water legs of firebox boilers would be more to locate broken stays, than to test the bulge itself. The bursting pressure of tubes is so high as compared with the bursting pressure of boiler shells, that there is little object in applying the test to bagged tubes in water-tube boilers. The condition of such tubes is best ascertained by the hammer test, and visual examination.

During the past year, the writer had an experience that will serve well to illustrate the usefulness of the hydrostatic test as applied to dents.

A small h.r.t. boiler was being removed from a flat car. The boiler was intentionally rolled off. The drayman thought that a steel boiler could stand any kind of rough usage. He learned differently, however, because the boiler struck first on one of its lugs. This caused a dent under and about the lug, about 15 in. in diameter and about $\frac{7}{16}$ in. deep. The measurements were taken with the aid of a templet made to the normal curvature of shell.

Advice was requested by the boiler owner as to what should be done. It was thought that the dent did little harm and that the boiler should be installed without the defect being removed; however, this was mere guess work. An hydrostatic test was applied. Measurements were taken after the pressure was applied and compared with those taken before its application. The dent decreased from $\frac{7}{16}$ to $\frac{5}{16}$ in. in depth and it was disclosed that the tip of the supporting bracket raised $\frac{1}{4}$ of 1 in. When the pressure was removed, the shell and lug assumed the normal defective condition. It can readily be seen that had the boiler been installed in its defective condition, when sufficient steam pressure would have been raised, one bracket or lug would have been raised from its footing and would have thrown all the weight on the other three, which in reality would have meant that two brackets diagonally opposite each other would have nearly all of the load thrown on them.

Steam pressure at the plant under discussion was raised in the morning and lowered at night. This would have caused a daily movement of the metal in the dent and might have caused crystallization.

You may judge for yourself as to the efficacy of a hydrostatic test as applied to boilers that are pitted and corroded. Let us assume for example, that we are testing a boiler of single riveted lap joint construction having a shell thickness of $\frac{5}{16}$ in. and that the diameter and other factors are such that the maximum working pressure is 100 lb. and the factor of safety is five. The calculated bursting pressure would then be 500 lb. The standard hydrostatic test pressure would be 150 lb. (1½ times working pressure).

It can readily be seen that the test pressure is so much less than the bursting pressure that the boiler would need to be badly thinned by corrosion before it would be expected to rupture; 500 is 3⅓ times 150.

By dividing the thickness of the shell by 3⅓ we get $\frac{3}{32}$. Let us assume that the joint efficiency is 50 per cent of the strength of the solid plate. Fifty per cent of $\frac{3}{32}$ is 3/64. Theoretically the boiler shell would need to be reduced to 3/64 of 1 in. over a large area, before it would rupture under a pressure of 150 lb. The same principle may be suitably applied to pitted tubes.

Many engineers almost hold their breath when they see the test gage register 1½ times the working pressure. The same engineers nod wisely and pass brilliant remarks when it is noted that their boilers stand up successfully under the test, and apparently attached more significance to the hydrostatic test than the hammer test and visual examination given before and after.

In summing up, it would seem if the foregoing remarks are true, that the mere application of a water pressure by no means constitutes a complete inspection and can never take the place of a visual examination and hammer test but that it constitutes a general measure of safety, reveals leaks and is useful for checking up on flat stayed or unstayed surfaces.

Remodeling a Large Boiler Room

REPLACEMENT OF OLD BOILERS AT ST. LOUIS PUMPING STATION PRESENTED UNUSUAL ENGINEERING PROBLEMS

TO EXPERIENCED engineers, the construction of a new power plant presents no unusual difficulty. Modern methods of construction are more or less standardized and while the procedure on each job is governed by local conditions, the work as a rule progresses in an orderly fashion from the laying of foundations to putting on the finishing touches.

In the case of a remodeling job, where certain equipment is to be renewed or added to, or where extensive changes are to be made in the arrangement of installed equipment, the problem with which the engineer is confronted is not so simple. Local conditions and individual considerations affect the procedure involved to a far greater extent, than on an entirely new project.

FIG. 1. THE BADEN BOILER ROOM, BEFORE AND AFTER REMODELING

(A) View taken before remodeling, showing new breeching in place. (B) The boiler room after remodeling.

Usually, on a job of this type, it is necessary to keep existing equipment in partial or full operation while the work of remodeling is going on. This complicates the course of action considerably and the engineer in charge is often forced to employ novel and unusual means to attain his ultimate object. In some instances, the order in which the various elements which comprise the plant are installed has to be reversed from that followed in a new plant.

It was a job of this type which confronted the engineers of the Water Division of the City of St. Louis, when they decided to replace the eight old boilers at the Baden Pumping Station with eight new ones. This station supplies a large part of the City of St. Louis with water and as there was not sufficient reserve capacity among the other St. Louis Pumping stations to carry the load of this station temporarily, it was absolutely imperative that the plant be kept in operation.

This is one of the older pumping stations in St. Louis and previous to making the changes, the boiler equipment consisted of eight 280-hp. O'Brien hand-fired boilers. These boilers were over 20 yr. old, and had about reached the end of their useful life. The shells were thin and tube renewals were frequent. Conditions as a whole were not conducive to the highest efficiency or best operating performance. The boilers were not equipped with stop and check valves and one occasion when a tube blew in one of them an employe was killed and before the operators could reach the valve on top of the ruptured boiler, the pressure in the remaining units had dropped from 150 lb. to 20 lb.

It was decided, therefore, to take out the old boilers and install in their place eight 420-hp. O'Brien water tube boilers of the Heine Type equipped with La Clede Christy chain grate stokers. It was also decided to put in overhead coal bunkers together with a complete coal and ash handling system so as to reduce the amount of hand labor required to a minimum.

The old boilers were set in one row in groups of two, as shown on the diagram in Fig. 8. Coal was brought into the boiler on small cars which ran on tracks laid in the firing aisle in front of the boilers. These cars were also used for the removal of ash.

Products of combustion were removed through a breeching which extended the entire length of the boiler room above the tops of the boilers at the rear. In the center of the room, this breeching was connected to the stack by means of a short length of breeching as shown.

After carefully considering the situation, the engineers came to the conclusion that the most logical thing to do would be to locate the firing aisle for the new boilers on the opposite side of the room. In other words, the space behind the old boilers would become the firing aisle for the

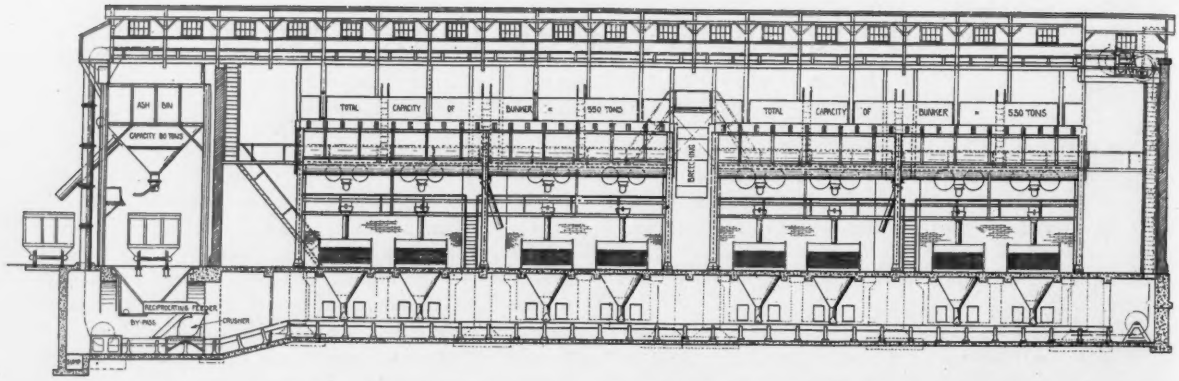


FIG. 2. LONGITUDINAL ELEVATION OF REMODELED BOILER ROOM

new boilers. It may be noted from the diagram that there was ample space behind the old boilers to permit of this arrangement.

Details of Reconstruction

One of the first steps in the reconstruction program was the construction of a new breeching. This was installed just above the fronts of old boilers as may be seen in Fig. 1 A, which is a photograph of the old boilers shortly after remodeling operations were started. A new stack was also built on the opposite side of the building from where the old stack was located. This was connected to the new breeching by a short length of breeching in the same manner, as in the old installation, except that it was located on the opposite side of the room.

As the old boilers were to be removed one by one, it was, of course, not feasible to use the boilers or boiler framework as a support for this new breeching. It was, therefore, suspended from the roof trusses by rods as shown in Fig. 5. The new main steam line which was also installed at this time was supported from the roof trusses in the same manner.

At approximately the same time that this breeching was being installed, a tunnel, or to be more exact, a trench was dug behind the old boilers. This tunnel was to accommodate the coal and ash handling equipment for the new boilers.

As soon as the new breeching was completed and the work of excavating for the tunnel had gotten well under way, the two end boilers, nearest the end of the building at which the coal entered, were dismantled. Before the work of dismantling could begin, however, it was necessary to disconnect it from the old breeching. This was done on a Sunday at a time when the load was comparatively light, and was accomplished by operating only the four boilers at one end of the room and then closing a damper at the point A in Fig. 8. A steel bulkhead was then introduced into the breeching at the point B, Fig. 8, after which it was a simple matter to cut off the breeching a foot or so, from the bulkhead. The result of this operation is shown in Fig. 4, which shows the bulkhead in place, and the first two boilers removed. This view also shows the foundations for the furnaces for the new boilers.

Immediately after the removal of the first two old boilers, two new units were erected. As stated previously, these were O'Brien water-tube boilers of 420-hp. rated capacity. They were equipped with Foster superheaters, installed in the combustion chamber, as shown in Fig. 6. This photograph shows the first two new units in course of erection and illustrates well, the method used to take care of expansion and contraction of the boiler. The rear header, it will be noted, rests on a hardened steel roller which is sandwiched between two hardened flat steel surfaces. It may be well to repeat here that the new boilers faced the opposite direction from the old ones.

Simultaneously with the erection of the first new units, a steam jet ash conveyor was installed in the tunnel underneath the new firing aisle. This steam jet ash conveyor was installed merely as a temporary measure, to serve the boilers while construction operations were in progress. As each battery of two new boilers was completed, this steam jet conveyor was extended to serve the new boilers. In

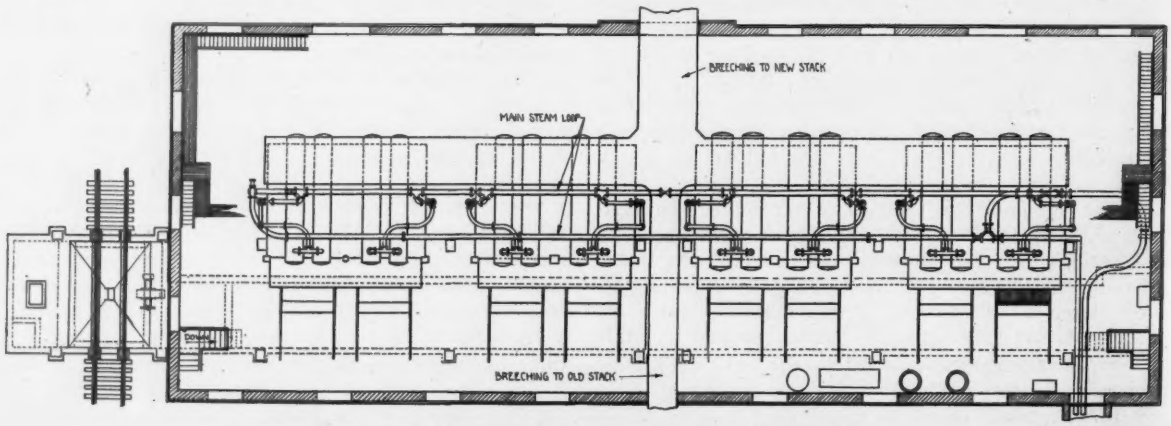


FIG. 3. PLAN OF NEW BOILER ROOM SHOWING PIPING

the case of the old boilers, ashes was removed by hand, but since the new boilers were equipped with chain grate stokers there was no way by which the ashes could be removed from the tunnel, and the temporary use of the steam jet conveyor became a necessity. It may be of interest to know that the steam jet conveyor is still in place, ready for use in case of emergency, although under normal operating conditions, the ashes are now handled by a pivoted bucket conveyor.

To deliver coal to the new boilers as they were erected, the track from the old firing aisle was extended to the front of the new units so that the coal cars could be run in front of the stoker hoppers.

Another feature of construction which represented a considerable problem was the construction of the overhead coal bunkers. There was not sufficient room to place them underneath the roof trusses, so it was necessary to install them in such a manner that the trusses passed through them. The details of this construction may be seen in Fig. 7 which shows the bunkers in course of erection. This coal bunker is installed throughout the entire length of the boiler room but is split at the center of the building where the breeching connects to the old stack. The bunkers are of steel parabolical in shape and are supported from heavy side girders as shown. To prevent corrosion from the action of moist coal they are lined with concrete. The total capacity of all bunkers is 1080 T.

In this manner all of the eight boilers were replaced, two at a time. As each pair of old boilers was dismantled, the old breeching was cut off, and as each pair of new

FIGS. 4-7. VIEWS SHOWING DETAILS OF REMODELING WORK AT THE BADEN PLANT

Fig. 4. Steel bulkheads were placed in old breeching when old boilers were removed. Fig. 5. New breeching and new main steam lines were suspended from above. Fig. 6. Details of new boiler settings. Fig. 7. Overhead coal bunkers in course of construction.

boilers was cut into service, they were connected to the new breeching. At the same time the steam jet ash conveyor was extended to serve the new boilers and a new section of coal bunker put up. This work required the greater part of a year and when the last of the new boilers had been installed and connected to the line, the finishing touches remained to be put on. Up to this time, the stoker hoppers had been filled by hand from the coal cars.

Richardson automatic coal scales were now placed in the downspout to each stoker and a pivoted bucket conveyor installed, to fill the overhead bunkers. An 80-T.

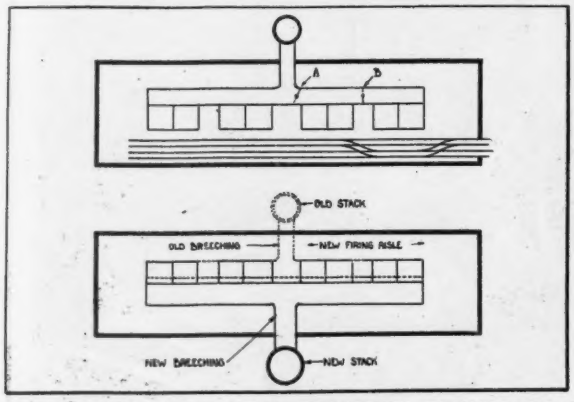


FIG. 8. DIAGRAM SHOWING PRINCIPLES INVOLVED IN MAKING CHANGES

overhead ash bin was also erected outside of the boiler room and a track hopper provided to permit of coal being delivered from railroad cars directly to the bucket conveyor. A longitudinal elevation through the boiler room is shown in Fig. 2. This shows the arrangement of the coal handling system. Figure 1B is a view of the firing aisle, after all reconstruction work had been completed.

While the work of remodeling was in progress in the boiler room, changes were also made in the main steam piping in the engine room. Before the changes were made the large pumping units were served by three separate steam lines. Due to the intended use of superheated steam with the new boilers, it was decided to replace these three old lines with two new ones. These two lines were to be connected to opposite sides of the new boiler room steam loop.

In making these changes, it was of course, necessary to install at least one of the new steam lines before the old ones were removed so that the pumping engines could be changed over to the new line with a minimum amount of delay. The three old lines were located against the wall and were connected into the sides of the engine receivers. One of the new lines, therefore was located just below the three old lines, and from this line, headers were connected into the tops of the engine receivers. The old supply lines were then disconnected from the receivers, the three old lines removed and the remaining new one put in their place. Figure 10 shows the two new lines in place with a portion of the old supply header still connected into the side of the receiver. The new supply header will be noted now feeds into the top of the receiver. The actual work of cutting an engine over from the old line to the new one required only a few hours, this work as a rule being done on a Sunday when the load was light.

Each of the eight 420-hp. boilers are equipped with Foster superheaters located in the combustion chamber. This location of the superheater has proved highly satisfactory. A constant degree of superheat (100 deg.) is insured and no trouble is experienced. In fact, when the superheaters are absolutely clean, the degree of superheat is a trifle too high so they are allowed to become slightly covered with soot.

All stokers are La Clede Christy chain grate stokers, driven from a line shaft in the tunnel below the firing

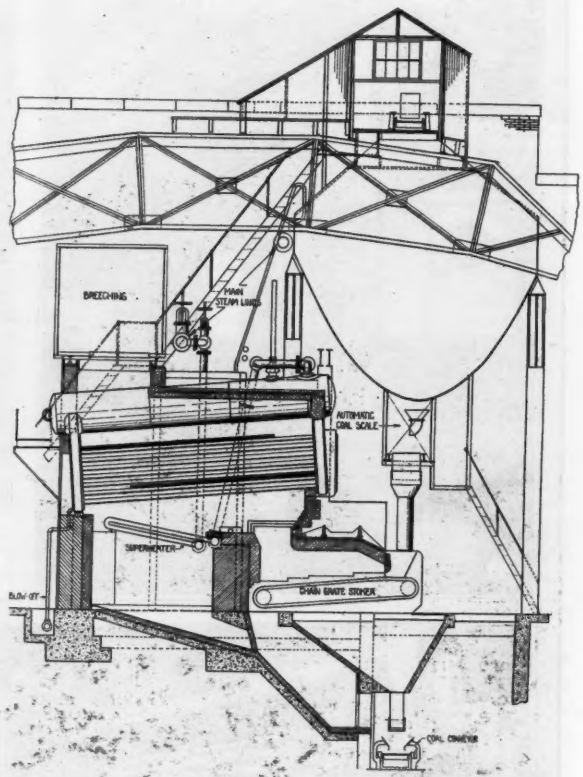


FIG. 9. SECTION THROUGH NEW BOILER INSTALLATION

aisle. This line shaft is driven by either of two E. H. Wachs high speed, vertical engines controlled by a Defender damper regulator. An electric motor is also provided for stoker drive in case of emergency.

Coal is delivered directly by railroad cars and is delivered to an American Pulverizer Co. ring crusher and then into the pivoted bucket conveyor which carries it to the overhead bunkers. The bunkers, it may be of interest to know are fitted with partitions so as to reduce the possibility of the fire spreading in the case of spontaneous combustion. If a fire does occur in any one section of the bunkers, or if for any reason it is desired to transfer coal from one bunker into another, a bypass arrangement is provided whereby the stoker is bypassed and coal from the bunkers is delivered through the boiler room floor into the bucket conveyor in the tunnel. The bucket conveyor then delivers the coal into any section of the bunker desired.

Another feature of interest in the design of the coal handling equipment, is the baffling arrangement in the coal spouts delivering coal to the stoker hoppers. This baffling is provided to reduce the impact of the downcoming coal as it is released from the automatic coal scales. This impact tends to cause caking of the coal in the stoker hoppers and results in an unequal distribution of the fuel

on the chain grate stoker. By placing suitable baffling in the downspouts, the coal is compelled to travel a zigzag path which effectively reduces the impact on the stoker hopper.

Operation

The Baden plant is operated on a strictly scientific basis, and all efforts are made to maintain the highest overall efficiency without sacrificing reliability. Each boiler is fitted with a General Electric Co. steam flow meter, Defender draft gages, Republic CO_2 recorders. Reliance Safety water column and alarms and Richardson automatic electric coal scales. A hand Orsat apparatus is also permanently connected to each pair of boilers with which the CO_2 recorders are checked, once a day.

Two Defender indicating pyrometers are provided, one for each set of four boilers. These indicate the temperature of the gases in the last part of each boiler. A Brown recording pyrometer is provided for recording the temperature in the breeching to the stack. This usually runs about 300 to 350 deg. F.

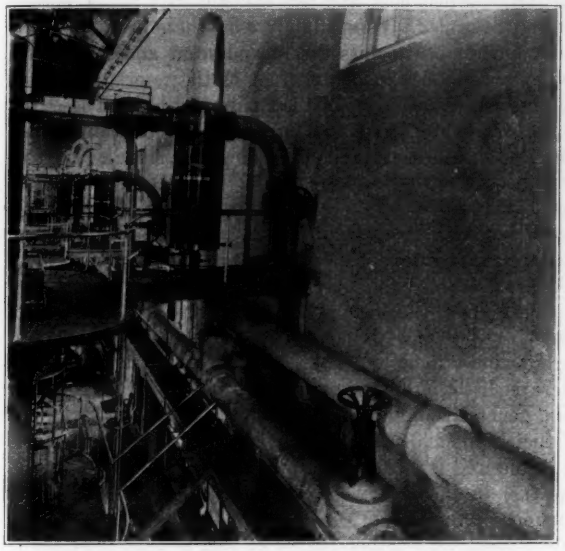


FIG. 10. VIEW IN ENGINE ROOM SHOWING NEW STEAM LINES

All feed water used in the boilers is measured by a 4-in. Venturi meter, located in the line leading to the feed water heaters. The latter are closed type heaters, heated by exhaust steam from the engines in the station generator room. The main pumping engines, of course, operate condensing and no exhaust steam is available from them.

Coal used at this plant at the present time has a heat value of about 10,000 to 11,000 B.t.u. per lb. and has a moisture content of from 5 to 10 per cent. At times it contains as much as 15 per cent ash.

Some idea of the performance of the station may be gained from the accompanying table, which is a comparison of the performance between the three pumping plants at St. Louis for one week. It will be noted that the load factor, that is the percentage of rated capacity at which the station is operated is lowest of the three, being only 76.2 per cent. This is due to the fact that the Baden Station has no reservoir capacity and must follow all the fluctuations of load. The overall efficiency is 70.35 per cent. Item No. 13 on this table, i.e., coal per water hp. per hr. is equivalent to the coal per kw.-hr. or per hp.-hr. of an electric generating station, and is included merely to give a general idea as to how the station performance compares with the performance of modern electric generating plants.

Considered as a whole the work done in the Baden station is an excellent example of engineering skill, and shows what may be accomplished in the way of improving an old plant.

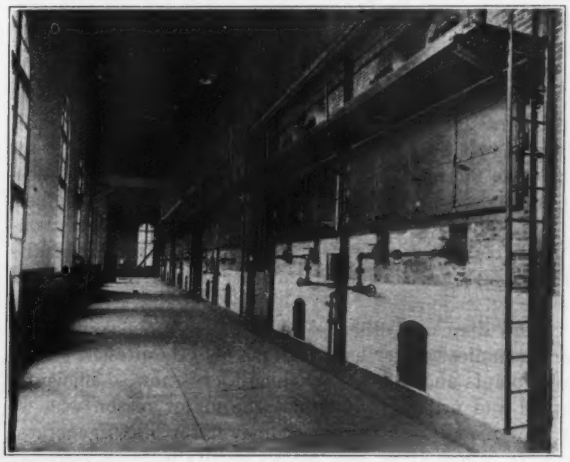


FIG. 11. THERE IS AMPLE ROOM BEHIND THE NEW BOILERS

All work of remodeling was planned and carried out under the direction of the construction section of the water division of the City of St. Louis.

Geo. A. Hoffman is chief operating engineer of the station.

Efficiency Report

Week of

December 23 to December 29, 1923

	BISSELL'S POINT	BADEN	CHAIN OF ROCKS
1. Total coal burned	732,600	711,800	661,900
2. Total water evaporated	4,673,000	4,733,000	4,456,000
3. Coal burned per hr.	4,361	4,237	3,940
4. Water evaporated per hr.	27,800	28,150	26,550
5. Lbs. of water per lb. coal	6.379	6.650	6.732
6. Equivalent evaporation	7.527	7.647	7.867
7. Efficiency	69.25%	70.35%	72.46%
8. Boiler hp. per hr	952	938	901
9. Rated boiler hp. per hr.	1,090	1,230	880
10. % rated capacity developed	87.3	76.2	102.2
11. Water pumped in gal.	396,965,000	278,940,600	689,730,000
12. Ft. lbs. per 1000 B.t.u.	120,700	124,200	66,300
13. Coal per water hp. per hr.	2.241	2.172	3.927
14. Coal per mil.gals. pumped	1,845	2,551	1,030

Credit is hereby extended to Leonard A. Day, engineer in charge of the construction and operating section of the water division, whose assistance in the matter of supplying information and data made possible the preparation of this article.

Range of speed control possible in the case of an induction motor provided with a rotor having collector rings connected to external adjustable resistances is about the same as the range of speed control obtainable with a shunt wound direct-current motor having a regulating rheostat in its armature circuit.

Underfeed Stokers and Midwest Coal*

CLINKERS HAVE OFFERED GREATEST PROBLEM; IMPROVED FURNACE AND BRIDGE-WALL DESIGNS ARE MEETING DIFFICULTY SUCCESSFULLY. BY JOSEPH G. WORKER†

WE MUST discriminate between theory and good practical operating engineering. Our problem in fuel burning is not entirely one of selecting the thermally most efficient system. We must consider those things that are connected with a combustion system that are vital factors in the ultimate results.

Flue gas temperatures, preheated air, hollow wall construction, etc., have shown that they can affect the overall efficiency of a combustion system from 5 to 10 per cent. These are not a part of any particular combustion system. In our endeavor to find that system that will give the best results from a dollar and cents basis for a particular condition great care must be taken to see that the results obtained are not attributed to other causes than the real ones.

More than any other piece of boiler room equipment, the mechanical stoker has made possible the present size of boiler plants and the rate at which fuel is now so efficiently burned and utilized. It is also the major reason why we are now installing a boiler horsepower for 6-kw. generator capacity, where 15 yr. ago, we installed a boiler horsepower for 2 kw. generator capacity.

There have been and there are many types of stokers that have been involved in this development. The underfeed stoker has played its part and has figured prominently in this progress.

We may have been correct in the past in holding that no stoker handles all grades of coal with the same degree of satisfaction. In that thought, however, we have mixed with it mechanical operating difficulties, that were not at all a part of the fuel burning system but were to quite an extent a part of the cleaning process of a fuel bed.

We have heard many times that the underfeed principle was all right for Middle West coals but there was too much clinker trouble. In a number of cases this statement, without analysis, prevented stoker manufacturers and users from looking through this trouble into combustion results in order to create the problem of determining what things should be done to overcome this trouble without disturbing the primary combustion system.

The East went through a partial situation similar to this years ago when the development of the underfeed principle was being taken up by some power stations. Some could see the virtue of this system when it was first developed, but it gave rise to endless discussion. It created thought and what was more, it placed the most severe construction upon the prevailing combustion systems at that time. Nothing could stop this movement after it once started and the faith and character of it led to further development. Improvements were made on one part or another of the controlling mechanism but the underfeed method of burning coal was probably more than any other single element, the reason for the success of the whole system.

A clear idea of the principles involved in a fuel bed of a multiple retort underfeed stoker is an important consideration. The inventor, Elwood Taylor, stated that in the operation of his stoker the fuel bodies in the several retorts constituted legs of a single fuel bed. This fuel bed burned with the incandescent fuel on top and the coking fuel underneath and extending back into the retorts. The fuel bed receives its support from the walls of the retort and owing to the cohesion and arching properties of the fuel as it swells during the coking process and is fed outwardly by the retort pushers, it is kept substantially free from the tuyere faces by arching over them. This operating principle and claim of the inventor has been demonstrated in research work in connection with this stoker and also substantiated by expert engineering testimony.

Few have considered that underfeed stokers use arches in the combustion process. These arches are made up of partially burned coal and are continuously being burned up and reformed. Immediately over these arches of partially burned coal comes the incandescent and major fuel bed extending across the openings of the retorts. Finally, the fine ash floats on top of the entire fuel bed. These particles of ash are small and originally independent pieces. The feed of ash is a gravity feed down the slope of the fuel bed and the movement of ash is induced by the introduction of cartridges of fuel. These cartridges of fuel introduced periodically give a weaving movement to the fuel bed and an outward feed movement across the mouth of the retort.

Very often the idea is advanced that the agitation of underfeed fuel beds is not proper for a high ash coal. A careful analysis of underfeed fuel beds will show, in fact, there is little agitation or mixing of the fuel bed of the kind generally supposed. The injection of these cartridges of fuel is so small that the movement at the time the coal is introduced is hardly perceptible to the eye. Arching of the fuel in the retort also relieves the pressure on these portions of the fuel in contact with the coal pushers when they retract for another charge of fuel so that their movement is always outward.

The formation and progress of the ash of an underfeed fuel bed is generally misunderstood. The feed of the ash is a gravity feed down the slope of the fuel bed, induced by the feed of the green fuel. A closeup view of the surface of a fuel bed would bring out clearly this idea of the travel of the fine particles of ash down the incline of the fuel bed and the inclination of the fuel bed must be such that the ash will effect this process.

Have we given enough thought to the machinery necessary to allow a fuel bed to function according to its principles? If there were no side walls nor bridge walls nor other refractory parts surrounding an underfeed stoker and nothing to retard the flow of ash from the top of the fuel bed to the bottom, would clinkers form?

Take, for example, a particle of ash in a fuel bed when stopped in its proper course down the slope, adheres to the side wall and backs up the oncoming ash and commences the formation of clinkers. This will gradually grow until it is built out into the fuel bed and underneath it and in some cases down into the retorts unless it is started on its course again.

Development work done on furnace construction for underfeed stokers has brought out side wall air plates, air-cooled crusher plates, water backs, etc., all to the end of keeping the ash from stopping in its course down the fuel bed. Side wall air backs are now being generally used in

* Abstract of address at the First Annual Power Meeting of the Chicago Section of the A. S. M. E.

† President, Stoker Manufacturers Association.

connection with underfeed stokers. These plates are working very satisfactorily and, of course, are much better than the refractory material that was previously used.

If we assume that the progress of the ash is not stopped but continues down the slope of the fuel bed, the next obstruction is the bridge wall. When multiple retort underfeed stokers were first installed they were equipped with dump grates and unless this part of the stoker was handled properly, the flow of ashes would be stopped at the bridge wall and a gradual accumulation and backing up of ash would soon result in large clinkers that would not only lie on the dump grates but would build up into the fuel bed.

Without disturbing the underfeed fuel bed principles, the designers tackled this problem and the result was what is commonly termed the rotary ash discharge. This device is necessary for continuous and uninterrupted progress of ash and clinker from underfeed stoker fires. It is obvious that under certain conditions of operation it would not be necessary continuously to actuate the crusher in the ash well and it is operated to keep in tune with the formation of ash as it proceeds down the slope of the fuel bed. Air backs and water backs are used on the front face of the bridge wall to prevent the stopping of any ash or clinker from continuing its course down through the ash wells through the crusher rolls into the ash pit.

What is happening today in the West is that some of these clinker problems are being solved and we no longer fear clinkers. At least, we are not stopping good engineering movements just because Western coals clinker. We in the West are getting over our fear of handling clinkers on any kind of a stoker. I do not believe either that we have exhausted our resources in this respect. The feeling is prevalent that we should leave the fuel bed alone, since it is established that it is an efficient fuel burning method and devote more thought and effort to taking care of conditions that such a fuel bed establishes and change the furnace or bridge wall or any other part of the whole installation that is necessary to get the practical operating results that are necessary.

WHOLE-SOULED sincerity combined with unbiased, humane discipline on the part of an executive, does more to promote respect, good will and co-operation among the employes of a plant than any other one thing.

Chart for Determining Steam Boiler Performance

BY GEO. GASTER

GIVEN THE feed-water temperature, the total heat of the steam, pounds of water evaporated per pound of coal, and the heating value of the coal in B.t.u. per pound, the combined efficiency of any boiler, furnace and grate may be obtained from a chart such as shown in the accompanying illustration. The same chart may be used to determine the equivalent evaporation, pounds of water per pound of coal from and at 212 deg. F., the factor of evaporation, boiler horsepower per pound of coal and pounds of coal per boiler horsepower per hour.

If the B.t.u. per pound is given per pound of dry coal, it is evident that the number of pounds of water evaporated per pound of dry coal must be used.

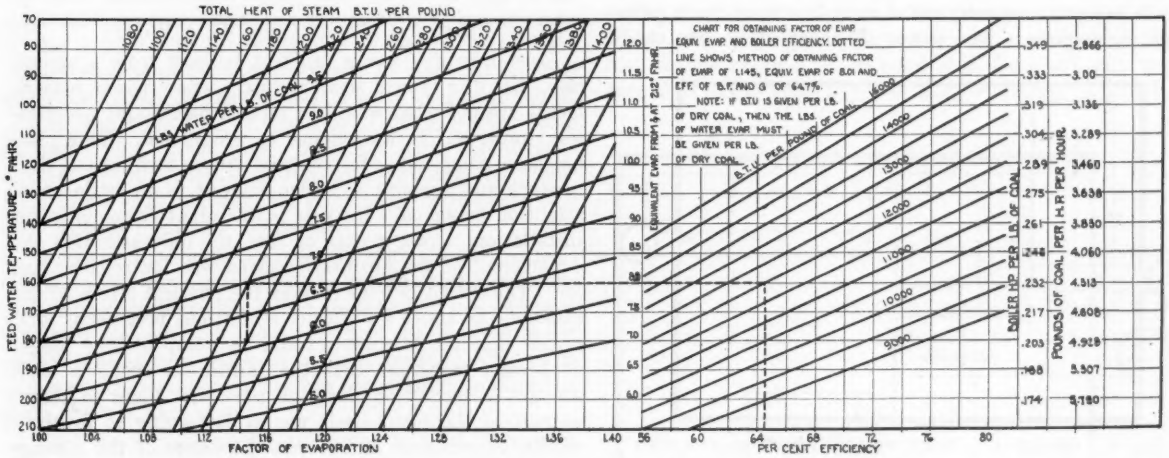

TOTAL HEAT OF STEAM B.T.U. PER POUND
FEED WATER TEMPERATURE ° FAHR.
FACTOR OF EVAPORATION
PER CENT EFFICIENCY
EQUIVALENT EVAP. FROM & AT 212° FAHR.
BOILER HP PER LB. OF COAL
POUNDS OF COAL PER H.P. PER HOUR
CHART FOR OBTAINING FACTOR OF EVAP. EQUIV. EVAP. AND BOILER EFFICIENCY. DOTTED LINE SHOWS METHOD OF OBTAINING FACTOR OF EVAP. OF 1.145, EQUIV. EVAP OF 8.01 AND EFF. OF B.F. AND G. OF 64.7%.
NOTE: IF BTU IS GIVEN PER LB. OF DRY COAL, THEN THE LBS. OF WATER EVAP. MUST BE GIVEN PER LB. OF DRY COAL.
B.T.U. PER POUND OF COAL
LBS. WATER PER LB. OF COAL

CHART FOR DETERMINING STEAM BOILER PERFORMANCE

To illustrate the use of this chart, assume a feed-water temperature of say 180 deg. steam with a total heat content of 1260 B.t.u. per lb., an evaporation of 7 lb. of water per lb. of dry coal as fired, and coal with a heat value of 12,000 B.t.u. per lb.

Starting at the left-hand side of the chart with a feed-water temperature of 180 deg., the dotted line shows the method of obtaining the factor of evaporation of 1.145, equivalent evaporation from and at 212 deg. of 8.01 lb. of water per lb. of coal, and the combined efficiency of the boiler, furnace and grate of 64.7 per cent. By extending the dotted line horizontally across the chart from the equivalent evaporation of 8.01 lb. of water per lb. of coal from and at 212 deg., we get .233 as the boiler horsepower developed per lb. of coal and 4.32 lb. of coal per horsepower per hour.

ASH IN coal comes principally from two sources; first, clay, sand or shale which was deposited during the laying down of the coal bed, and second, those substances derived from the original vegetable matter. A third source of ash are those impurities which become mixed with the coal at the mine or when it is in storage. Picking, screening and washing can be used to remove some of the ash forming substance.

Wanted: A Policy in Industrial Power Plants

NEGLECT OF THE POWER PLANT INEVITABLY RESULTS NOT ONLY IN ITS NOT PAYING DIVIDENDS BUT IN ITS ACTUALLY BECOMING A LIABILITY. BY DOUGLAS HENDERSON*

IT IS interesting, after making an intimate study of power plants connected with representative American industries, to tabulate their symptoms and ailments for the purpose of diagnosis. It is safe to say that most of them are suffering from a malady that can best be called "make-shiftitis." It is a malignant growth and is the final result after years of improper nourishment. Its epidemic proportions warrant careful consideration and deep analysis in order to determine its cause, effect and cure.

One of the vital factors in every industry is the force which makes the wheels of production turn, for without production all sales effort, all advertising and all executive ability would be useless. Quite naturally, in the pioneer days, the cheapest and most satisfactory source of power was the steam boiler, generating steam from coal and this steam being turned into useful work by one or more reciprocating engines. The power thus developed was easily

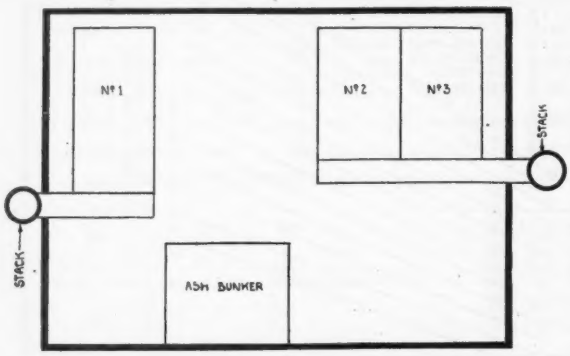


FIG. 1. ORIGINAL LAYOUT WHICH PROVIDED FOR TWO STEEL STACKS

distributed around the plant by belts and pulleys. Coal was relatively cheap, the plant covered only a limited area so that the distribution of power in this manner accomplished all that was expected and attention was directed towards developing the industry by sales stimulation and advertising.

As the population of the country grew so did its demands, and with the advent of national advertising the field became almost unlimited. To meet the increased demand for merchandise, plant expansion had to be considered and carried out, against which there was no argument. The boiler room in most cases was sufficiently large at the beginning to take care of some plant growth and consequently it received but scant attention. The enthusiasm of larger earnings swept the power requirements into the background.

Conditions changed and with the passage of a few years, the power plant reached a point of demanding attention, either due to break-downs or inadequate capacity. A quick solution was effected which usually took the form of adding a new boiler, or bolstering up on the engine side of the power plant in some way or another. After a few such temporary expedients, the plant developed an acute case of "make-shiftitis" and in practically every instance these plants are now paying the piper. The management continuously kicks on the coal bills while the operating force offers the thread-bare alibi that the equipment is shot-to-pieces and the plant capacity is deficient. To straighten out a snarl like this presents a delicate problem and one that has to be accomplished with technical skill and unlimited tact.

In answer to "make-shiftitis" is the adoption of a power policy in much the same way that policies govern sales and finances. Once the plan is determined upon, it becomes a matter of keeping the plant in operation while permanent improvements are made in conformance with the estimated growth of the industry. The power policy permits the formulation of a plan and once established this plan provides something definite to work towards, taking care of all requirements as time goes along.

PRACTICAL APPLICATION OF A POLICY

Just how this works can best be seen from a specific case, that of a typical small industry whose power requirements are not what would be termed paramount nevertheless, important in the scheme of production. This plant has been going along for the past 20 yr. turning out their product and reaping a golden harvest, with little or no attention being paid to their power plant since its initial installation. As a matter of fact, the only attention this department of the business received was for repairs, fuel, etc. The sketch in Fig. 1 shows the physical layout of this plant up to June, 1923, when conditions became so intolerable that the inevitable could be postponed no longer. It became apparent that the failure to spend a small amount of money regularly on the boiler plant to keep it abreast of the plant itself was at last going to involve a capital expenditure and it was the desire of the management at this time to study the situation carefully so that future growth would be assured. This company had, at last, reached the point of adopting a power policy and it was their intent that, once established, they would follow it faithfully.

Briefly, the plant situation was this: Boiler No. 1 was a 175-hp. return tubular unit in good condition, while Nos. 2 and 3 were 125-hp. boilers of the same type but very old. These two were fast reaching a point where boiler inspection would demand lower steam pressures for the sake of safety. As the diagram shows, No. 1 boiler was connected to a steel stack 75 ft. high and the other two units had their draft requirements supplied by another steel stack of the same dimensions. The ash bunker was placed in the boiler room at a time when no thought was given to the possibility of adding any more boilers. This outline indicates how the boiler plant was administered. First two 125-hp. boilers were installed and at a later date, as a quick solution to some shortage in capacity, one 175-hp. boiler was added with its own stack. Finally, rather recently, an ash handling system was installed, which was nothing but disassociated equipment put in for the sole purpose of meeting the fast mounting demands of the growing business but never fully succeeding in doing so.

When a sudden wind-storm carried away half of the stack on boiler No. 1 Mother Nature with a single stroke set the boiler plant years behind the business and for the first time the seriousness of the condition was realized. Of

*Chief Engineer, Fuel Engineering Co.

course, it was possible to effect another temporary solution but fortunately the management took a much broader viewpoint. It was time to work out a plan to cure the attack of "make-shiftitis" and to furnish a guide for future extension.

First a new 175-hp. boiler was placed adjacent to the one already in place. A single radial brick stack was erected capable of taking care of all future growth in the boiler plant, in this way eliminating the two steel stacks which had always been a source of expense and care. This change required a new steel breeching, which was nicely located without any objectionable bends. Sketch, Fig. 2, gives an idea of the present layout. Considering the future, it was realized that ultimately it would be necessary to replace the two old 125-hp. units and for that reason the ultimate plant was figured as consisting of four 175-hp. boilers. The new stack and breeching was designed with that idea in mind.

Since the present demands for power did not require any more boiler capacity than that shown in Fig. 2, the apparently oversize stack and breeching was merely part of the plan adopted. When the additional boilers are needed, the rest of the equipment will be ready. It is much easier and much cheaper to put in extra large equipment in this connection than it would be to add more breeching and stack at a future time. This is a particular demonstration of an economy arising from treating the power plant in the same manner that every other department of a well organized business is treated.

With the knowledge that the old boilers faced condemnation in the near future, if the present steam pressure were carried on them, the boiler room piping was designed to permit use of Nos. 2 and 3 boilers on 40-lb. pressure for use in process work such as boiling, pickling, etc. The high pressure steam from the two other units supplies the steam engines, pumps, etc.

Here was a plant that realized the folly of their ways before it was too late and from the apparent wreckage a definite plan was evolved. Now they have a scheme to work towards and any additions which will be made in the future will fit in with the arrangement laid out. "Make-shiftitis" is cured for all time. The ideal remedy for this disease is, of course, to prevent it entirely by giving thought to the power plant before the coroner has to be advised.

Consider the small paper mill in New England as another typical example. Two return tubular boilers operate under hand-fired conditions and when they were originally installed gave entire satisfaction. Since then the equipment has deteriorated and the production of the mill has gone up, both influences placing a tremendous load on the back of the poor old boiler room. The inevitable happened and it became more and more difficult to carry the steam pressure. The first solution was to get the best coal that could be bought, which was done at a rather heavy cost but it was no solution at all. It was a makeshift. The stack is too small making the draft insufficient. At the same time the boilers are in a bad state of decay simply because there is never an opportunity to put them into shape. At some time or other, this plant will have to pay for the lack of wisdom in the past in failing to keep the boiler plant apace with the rest of the mill.

When it comes time to pay, the costs will be heavy, and every year the final payment is postponed means that much more loss. The solution in this case will be a new boiler plant for nothing can be done with the present one towards curing the dreaded ailment "make-shiftitis." The patient is bound to die. The new plant will undoubtedly usher in the power policy which has heretofore been disregarded.

Neglect Often Leads to the Expenditure for a New Plant

These two instances are typical of conditions in many power plants connected with the average-sized industry, the only difference between them being the fact that in one case the change was worked before it was too late, while in the latter a new plant will be the only recourse. The other side of the argument, namely how well the power plant improves with the rest of the organization when proper attention is directed to it, can be seen by using another actual example.

It is that of nationally known industry located in the east. Five years ago, the plant consisted of six 300 hp. water tube boilers under which bituminous coal was burned on natural draft stokers. In the campaign at that time for saving coal, some boiler room instruments were installed, which included a steam flow meter on each boiler. The fuel economy came as expected and the dividends were enormous but to avoid any possibility of falling back to the

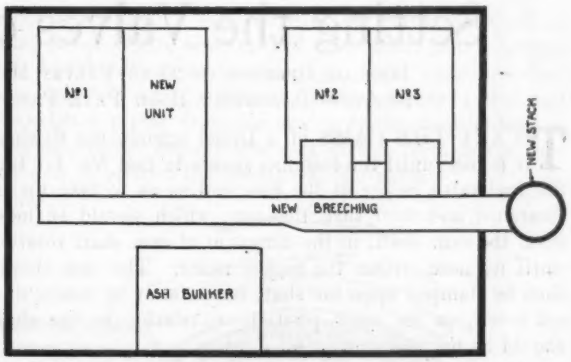


FIG. 2. NEW LAYOUT WHICH PROVIDES FOR FUTURE GROWTH OF THE PLANT

original condition these same instruments were utilized to keep a daily check on the plant operation. The data furnished by the steam flow meters was particularly valuable because when plotted month by month it indicated the variations in the steam demand of the plant. After one year of such records, it was possible to combine the power plant performance with the outlook of business for the coming year and to determine at that time what improvements would have to be made in the boiler room to carry the expected business. At this particular time, the cautious directors saw no reason to add more capacity and based their judgment, not on a guess but on facts.

Resume of the next year's outlook of business together with the physical condition of the power plant indicated that more capacity would be needed and accordingly a plan was drawn up that would take care of the deficiency and avoid the dangers of "make-shiftitis." Two new 500 hp. boilers equipped with chain grate, forced draft stokers were decided upon and ultimately installed. The future growth of the plant was to proceed along the line of removing the six 300-hp. units and replacing them with four 500-hp. boilers equipped with the same stoking apparatus as the two already decided upon. The final plant would

then consist of six 500-hp. boilers or a total of 3000 hp. installed horsepower and capabilities of developing 200 per cent of rating with the new type stokers.

Today, the growth of this plant has been so rapid that two more 500 hp. boilers have been installed even before the replacement of the 300-hp. units could be started. The plant is burning river anthracite at a ridiculously low figure instead of the original bituminous. Fuel economy instituted five years ago still maintains so that the best results are obtained from the boilers installed. The power plant is closely integrated with the development of the business so that at no future time will there be any deficiency in boiler capacity which would seriously interfere with production.

That is the practical application of a power plant policy. It matters not whether the plant is large or small, nor does its location affect the consideration. In these times of keen competition in industry, it is imperative that waste be done away with and what is even more important, continuity of service and production must be assured. The opportune adoption of a power policy and the gradual working along its lines will fortify the plant against conditions leading to shut-downs and costly interruptions to service, the actual cost of which in no case can be computed. It takes away a host of cares and worries from the executives, for it merely becomes a matter of having the facts available as to when a certain change or addition should be made in conformance with the predetermined plan. It is for all the world like the settlement of financial problems by the budget system and nobody will deny the value of this idea.

Difficulty often lies in establishing the importance of the power side of any business, for in too many cases it is looked upon as a necessary evil. Once it has fallen into that unfortunate position it soon becomes something to be put aside at all opportunities and to place its destiny in the hands of an operating force commissioned with the task of burning coal and supplying power. When this atmosphere engulfs the power plant, we begin to hear such statements from the operating force as, "I can't get them to do anything down here," or "They won't spend a nickel on new equipment." Discontent is bred and with the entrance of discontent comes bad operation, fuel wastes and all of the attendant evils. Finally the coal bill is found to be increasing steadily and there follows the usual excitement that finally winds up in a quick remedy for a trouble of long standing. The plant can then be said to suffer from "make-shiftitis" and the cure rests with the management.

Setting the Valves of a Diesel Engine---II

TIME OF OPENING OF FUEL VALVES MUST BE ACCURATELY AND DEFINITELY KNOWN TO AVOID DANGEROUS HIGH PEAK PRESSURES. BY H. F. BIRNIE AND R. C. BAUMANN

TO SET THE CAMS of a Diesel engine, the flywheel is turned until the trammel points to fuel No. 1. Lift the fuel-valve rocker at the cam end so as to take up all clearance and then turn the cam, which should be loose upon the cam shaft, in the direction of cam shaft rotation until its nose strikes the rocker roller. The cam should then be clamped upon the shaft temporarily by means of a set screw, or its exact position in relation to the shaft should be marked by a chisel scratch.

Again the flywheel is turned over forwards until the trammel indicates the opening of No. 1 exhaust valve. All the valves for the three cylinders are set in the manner just described after which the cam shaft should be removed from the engine and the cams permanently locked in place by means of keys. Before removing the cam shaft from its bearings do not forget to punchmark the cam shaft gear and its meshing pinion so that when the shaft is replaced the gears may be remeshed exactly as they were while the timing was being done.

After the shaft is replaced, the complete setting should be checked before starting the engine. The timing of the exhaust, inlet and starting valves need not be exact, one or two degrees either way from the desired setting will not affect the performance of the engine appreciably. This, however, does not hold true for the fuel valve for the actual time of opening of this valve must be accurately and definitely known. Too great a lead may cause dangerously high peak pressures. The commonly used method of checking the fuel valve timing is to turn on the injection air and then have the engine barred over slowly while an observer listens at an open indicator cock of the cylinder in question. As soon as the fuel needle begins to lift, the hiss of the injection air escaping into the combustion chamber can be plainly heard through the open indicator cock.

If the setting of the fuel cam is found to be out slightly it can be rectified by loosening the two fillister head cap screws which clamp the hardened cam nose to the cam body and slipping the nose into adjustment. The nose piece must then be carefully backed up by shims, otherwise it will slip out of adjustment. Two more events for the engine in question must be timed, they are the opening of the starting valve and the position of the fuel pump eccentrics. On stationary engines two types of starting valve gear will be found. In the one the starting valve, located in the cylinder head, is actuated directly by a cam on the cam shaft through the medium of a rocker arm exactly as are the inlet and exhaust valves. The rocker arms are pivoted upon eccentric bushings which allow them to be lifted off their cams after the engine has started. Since the setting of this valve is simply a repetition of the process followed for the other valves nothing more need be explained here. These valves should open between 10 deg. before firing top center and firing top center.

FOUR-CYCLE ENGINES WILL HAVE TWO CYLINDERS WITH STARTING VALVES

It must be remembered that the starting position of the engine does not correspond to the time of opening of the starting valve. The starting valve should be timed to open before firing top dead center while the starting position is necessarily after top center. Stationary four-cycle engines will have at least two cylinders equipped with starting valves. Starting air will be admitted to these cylinders every other revolution. The air is introduced at the beginning of what would otherwise be a firing stroke. The inlet and exhaust valves continue to open and close during starting exactly at the same time and in the same sequence as during normal running under fuel.

In the case of the air-opened starting valve, the valve located in the cylinder head is merely a spring loaded check which carries at its upper end a small piston. Com-

pressed air, referred to hereafter as "pilot air," acting upon this miniature piston causes the starting valve to open against the resistance of its coil spring which otherwise insures its remaining in the closed position. It is obvious therefore that the valve controlling the flow of the pilot air, only, must be timed. This valve, called the pilot valve or distributor valve, is actuated by a cam on the main cam shaft. There is a separate pilot valve for each cylinder which is equipped with a starting valve, for the three-cylinder engine in question there would be two pilot valves. This pilot valve should be set to begin opening 10 deg. before firing top dead center. The adjustment of this valve completes the timing of the starting system.

Setting the fuel pump eccentrics will be dealt with in a later article since this is a subject best considered in

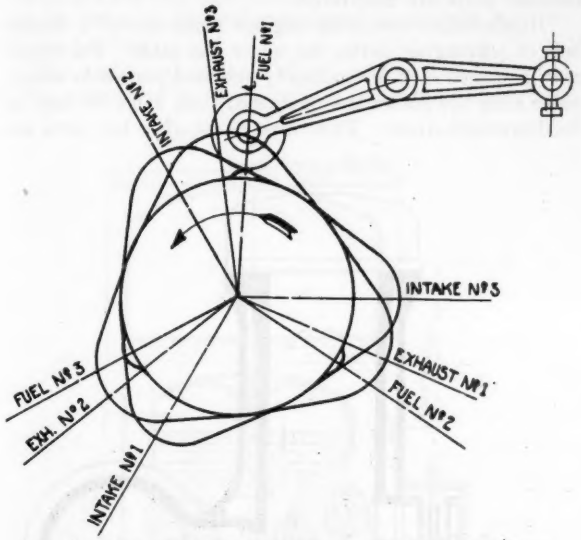


FIG. 1. END VIEW OF CAM SHAFT SHOWING POSITION OF CAMS

connection with the fuel valves themselves. After an engine has been in service for some years the wear of the gears between the crank shaft and the cam shaft and the thrust bearings of the vertical shaft will cause all the valve events to occur too late. This should be compensated for by slightly advancing the gear on the end of the cam shaft. The engine designers have provided for this adjustment in various ways.

One way is to have the gear rim separate from the gear spider and hub. The spider only is then keyed to the shaft while the gear rim is bolted to the spider with cap screws or through bolts. The bolt holes are elongated so that the gear rim may be rotated slightly while the cam shaft remains fixed. Other manufacturers prefer to have the cam shaft in two parts. One length carries all the cams while the other is simply a stub shaft the only function of which is to carry the gear. The two pieces of shaft are coupled rigidly together by means of a conventional flange and bolt coupling. The coupling bolt holes are elongated to allow of some adjustment of one in relation to the other to compensate for gear wear. Engineers experienced in the use of the indicator and who are able to interpret indicator diagrams correctly can set the valves to open at the best time by taking weak spring indicator cards. This method is not recommended unless one is sure that his indicator rigging is really capable of giving accurate cards. Such an indicator motion is a great exception.

Valve Gear Becomes Noisy Due to Excessive Clearance

Pounding of exhaust valves may often be traced to an excessive lead. If the lead is too great the valve must open against a considerable gas pressure in the cylinder. Excessive clearance between the cam rollers and the cams will also cause noisy valve gear. If the exhaust piping between the engine and the silencer or muffler has become partially

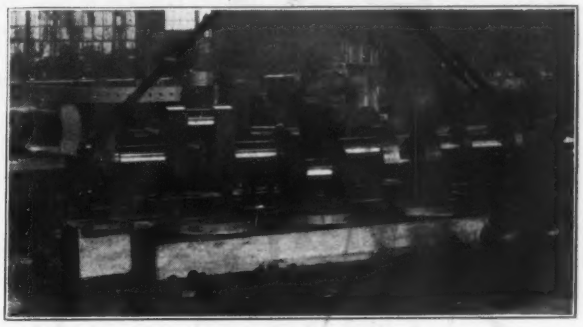


FIG. 2. THREE CYLINDER CRANK SHAFT BEING SWUNG INTO PLACE

clogged, the engine will act as if the valves were out of time, hence before altering the valve setting it is always well to take down the exhaust piping and make sure that it is clear. If a fuel containing much sulphur is used and the exhaust piping from the engine to the stack is long, a hard sulphurous deposit is almost sure to form in the piping and to restrict the passage of the gases.

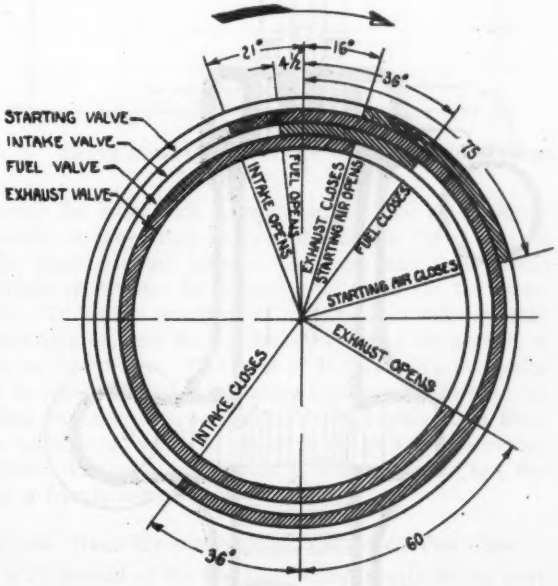


FIG. 3. TIMING DIAGRAM FOR A BUSCH-SULZER TYPE B 30 4-CYCLE ENGINE

Pounding of the fuel cam may be caused either by too much initial compression of the fuel needle spring, excessive clearance or by a needle which is binding in its guide bushing. If the clearance is reduced at any time one must be sure to check it again immediately after shutting the engine down and while it is still hot and again after the engine has cooled off.

Timing two-stroke cycle engines is simple to understand and to carry out as compared with the timing of four-cycle engines because there is only one revolution of both the crank and cam shafts per cycle and there is one and sometimes two valves less to consider. For one complete cycle of all events, the crank shaft and any valve or cam shafts make one revolution.

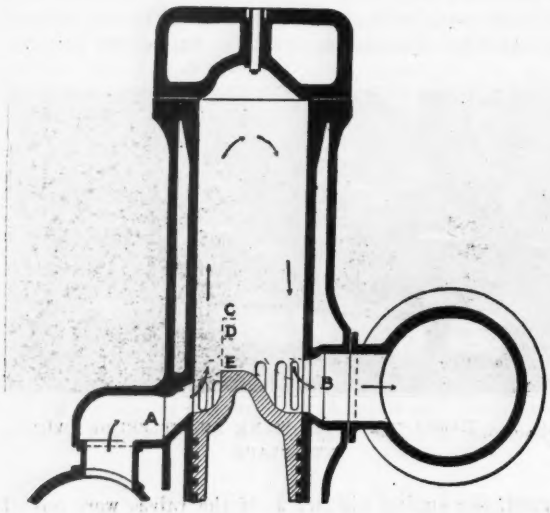


FIG. 4. FRESH AIR AND EXHAUST PORTS IN SIDE WALL OF 2-CYCLE ENGINE CYLINDER

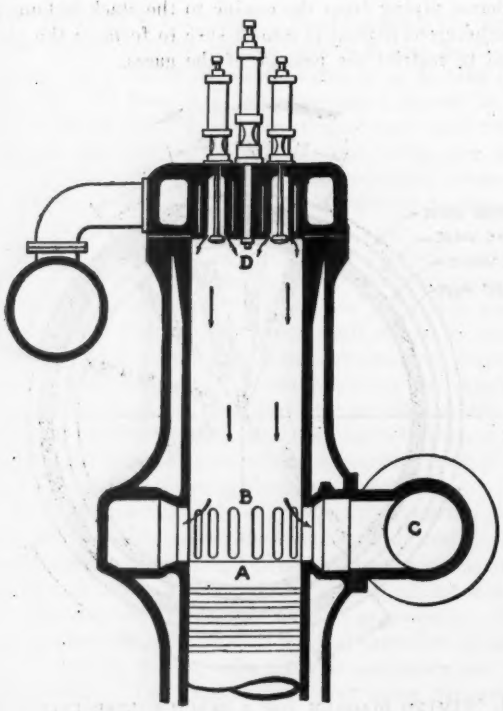


FIG. 5. SCAVENGE AIR IS SOMETIMES ADMITTED THROUGH POPPET VALVES IN THE 2-CYCLE ENGINE

All two-cycle engines exhaust through ports in the lower end of the cylinder barrel. These ports then serve the same purpose as the poppet exhaust valve of the 4-cycle engine. Since the ports have a fixed location and their opening and closing is controlled by the movement of the working piston they can be removed from further consideration in so far as valve timing is concerned.

In smaller two-cycle engines the fresh air charge is also introduced through a single row of ports in the cylinder barrel placed slightly below the exhaust ports. These, too, have a fixed position and require no consideration from the operator. In some large two-cycle engines the scavenge air is introduced through two, three or four poppet valves in the cylinder head all opening simultaneously. These valves are actuated by rocker arms in the same way as are the valves of the conventional four-cycle engine. One cam and rocker arm may open all the valves. These valves should be set to open some 10 to 15 deg. after the exhaust ports are uncovered.

Busch-Sulzer two-cycle engines make use of a double belt of scavenging ports, one above the other. The upper row is opened by a mechanically operated poppet or rotary valve after the piston has uncovered them some 30 deg. on its downward stroke. This valve closes, after the ports are covered by the piston on its upward stroke, hence although the opening is timed by the timing of the valve, their closing is timed directly by the movement of the working piston.

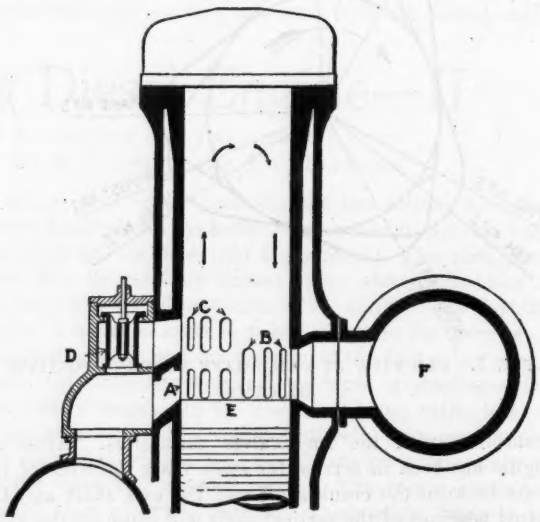


FIG. 6. BUSCH-SULZER 2-CYCLE ENGINES USE DOUBLE ROW OF SCAVENGING PORTS

Busch-Sulzer type C two-cycle engines employ a rotary valve to control the flow of air to the upper scavenge ports. These valves form a continuous horizontal shaft driven by bevel gears off the vertical shaft. Immediately after the bevel gears there is interposed a slip clutch which disengages should the rotary valves stick for some reason. The slipping of the clutch prevents the gears from being stripped or the shaft from twisting off. After the clutch has once slipped the shaft must be completely retimed. On this engine the fuel valve should open 7 deg. before top center and close 50 deg. after. The starting valve opens on top center and closes 102 deg. after. The exhaust ports are uncovered 61 deg. before bottom dead center.

Fuel valve designs for air-injection Diesel engines will be treated in the next article of this series.

Waste Heat Boiler For Oil Engines

TESTS HAVE BEEN CONDUCTED WHERE 60 PER CENT OF THE WASTE HEAT FROM THE ENGINE HAS BEEN RECOVERED

ROUGHLY SPEAKING, one-third of the heat of the fuel in an ordinary internal combustion engine is turned into useful work, the remaining two-thirds being carried away to waste, half by the cooling water and half by the exhaust gas. In the Clarkson boiler of British manufacture, the already heated cooling water is used to abstract a large portion of the heat of the exhaust gas. This boiler can be used either to provide a supply of hot water, or alternately a supply of steam, according to the manner in which it is operated. It requires, moreover, none of the personal attention which steam boilers demand and the steam or hot water produced is obtained with no expense for fuel.

This waste heat boiler is shown in Fig. 1. It consists of two cylindrical shells one within the other. The upper

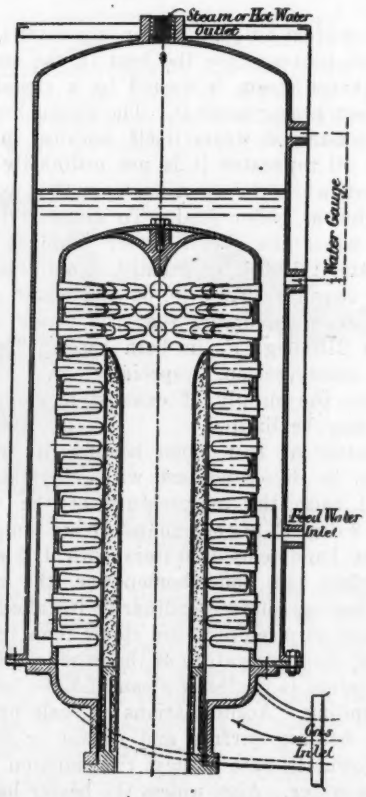


FIG. 1. TAPERED THIMBLES EXTEND INTO THE GAS FLOW PASSAGE

end of each shell is closed by a domed end and the open ends are connected by a bolted flanged joint. The space between the shells contains water and steam and the hot exhaust gas from the engine circulates within the inner shell, the heating surface of the latter being increased by a large number of internally-projecting thimble-shaped tubes.

These tubes extend from the wall of the inner shell until they are almost in contact with the gas outlet pipe in the center and as they are staggered vertically the flow of the hot gas is effectively broken up. The tapered form of the thimbles enables them to make a perfectly tight joint without being expanded into the shell plate and the boiler pressure helps to maintain this tightness. As they are held at one end only, they can expand individually in accordance with the variation of thermal conditions.

Circulation in the tubes appears to be of a pulsating nature, steam being generated which can only escape by

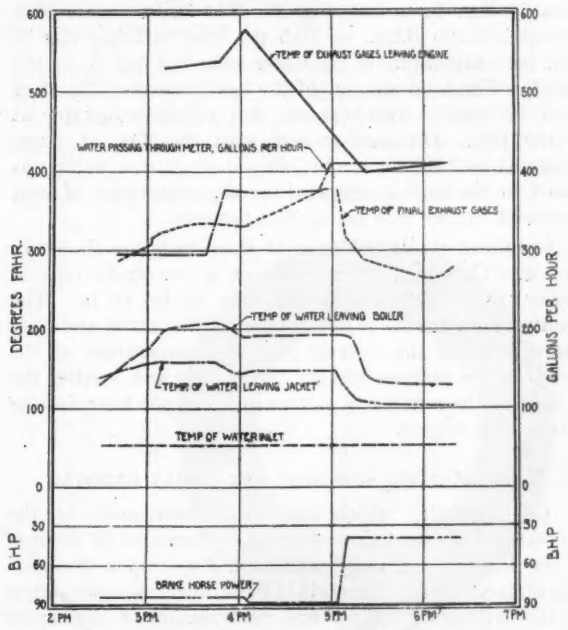


FIG. 2. CHART SHOWING RESULTS OBTAINED DURING TESTS

blowing the water back intermittently. This action seems effective in preventing deposit of scale in the tubes. A baffle plate situated between the inner and outer shells prevents feed water from impinging upon the hot inner shell. In boilers working in conjunction with internal combustion engines the hot jacket water of the engines is used as feed water. The level of the water in the boiler can be regulated by an automatic arrangement comprising a float chamber, external to the boiler, containing a float, the spindle of which is kept in a slow reciprocating motion. The effect of friction is thus overcome and the float is free to indicate the water level.

WASTE HEAT RECOVERY AMOUNTS TO 60 PER CENT

With the aid of the Clarkson boiler, nearly 60 per cent of the waste heat of the engine was recovered. When some of the jacket water was bypassed, in order to reduce the feed to the boiler, the latter proved itself capable of delivering 2600 lb. of water per hr. at boiling temperature. There was never any indication of back pressure on the engine exhaust, even when the engine was overloaded to 90 b.hp. At the full load of 84 b.hp. the oil consumption was a few per cent better than before the boiler was fitted. The reason for the absence of back pressure and the slightly improved consumption of oil is attributed to the

fact that the boiler acts as a condenser for the hot exhaust gas, suddenly chilling it and reducing its volume and thereby assisting its removal. The boiler also acted as an effective silencer.

With the engine developing its full load of 84 b.hp. and the whole of the water supply, namely, 4230 lb. per hr. being fed to the boiler, the following results were obtained on test. The engine consumed 44.52 lb. of oil per hr., of a specific gravity of 0.878 and a calorific value of 18,500 B.t.u. per lb. This works out to a consumption of 0.53 lb. of oil per b.hp.-hr. The heat developed per hr. by the combustion of the fuel was 823,620 B.t.u. and of this 300,330 B.t.u., or 36.4 per cent of the total was recovered from the jackets by raising the temperature of the water from 54 deg. F. to 125 deg. F. The boiler recovered a further 169,200 B.t.u., or 20.5 per cent utilizing this to raise the temperature of the water from 125 deg. F. to 165 deg. F. The total amount of the heat recovered therefore from the engine was 56.9 per cent of the original heat of the fuel. On another test with the flow of water regulated to 2912 lb. per hr., the whole of this water was raised to the boiling temperature, the percentage of heat recovered in this case being 56.9 per cent.

Graphical results of some of these tests are shown in Fig. 2. These tests were made on a two-stroke type of engine, the cylinders of which were 12 by 14 in. The results shown are the power developed, the initial and final temperature of the exhaust gas, the temperature of the water to the jackets, leaving the jackets and leaving the boiler and the number of gallons of water per hour flowing through the engine.

Tarry Matters and Soot Are Easily Removed

One difficulty which has been experienced in the recovery of the waste heat from the exhaust of oil engines is the deposition of tarry matters and soot upon the heating surfaces. Such a deposit is quite likely to occur owing to the chilling of the gas and condensation of the vapors by the relatively cold tubes. This effect is to bring about a serious reduction in the rate of heat transmission. The cleaning of soot and tar from the interior is not easy, but the Clarkson type lends itself to an extremely simple method. The deposit can be burnt off without any injury to the boiler. It has been found that the thimbles may be made red hot without damage. No harm will therefore occur if the exhaust gas is passed through the boiler when there is no water in it.

Design, construction and tests of this boiler were carried out in England, and the reported results as given above are from Engineering of London.

Upon the chief engineer of a power plant falls the responsibility for safety of working conditions in the plant. His influence over the men, his knowledge of the work, and his ability to guide in right methods, make him a commanding figure. But it must also be remembered that the engineer is not always supported by the employer. If safety is sacrificed to production, if there is an intimation or request to look the other way when violations of law or of practice are to be seen, and if there is failure loyally to support the man on the firing line, then he is placed in a helpless position and loses the lead that should be his. Every man connected with the plant should back up the chief engineer when he is vigilant for the best interests of the men under his direction.

Open vs. Closed Feed Water Heaters

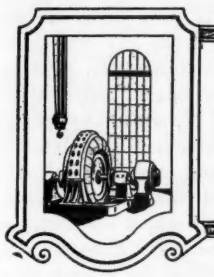
By C. C. Brown

HEATING BOILER feed water by means of exhaust steam effects a saving of about 1 per cent of fuel for each 11 deg. F. rise in the temperature of the feed water. Besides the fuel saving, heating the feed water increases the actual steaming capacity of the boilers. The portion of the heat that is required to turn the water into steam supplied before the water enters the boiler, diminishes the work of the heating surfaces, or if, on the other hand, the transmission of heat remains the same as before, more steam will be generated from the same heating surface, and from the same amount of fuel and hot gases where the feed water is preheated. The increase in steaming capacity is in nearly the same proportion as the fuel saving. About 1/7 of the fuel is saved by heating the water from 50 deg. to 210 deg. F. and the steaming capacity is increased by one sixth.

The saving from an open heater is greater than that from a closed heater, since the heat in the condensate from the exhaust steam is wasted by a closed heater, while the open heater saves it. The closed heater also wastes the condensed steam itself, because in the absence of an oil separator it is not ordinarily suitable as boiler feed, while the open heater makes use of this distilled water as boiler feed. To make 7 lb. of hot boiler feed water the closed heater requires 7 lb. of cold water and 1 1/6 lb. of exhaust steam, whereas the open heater requires only 6 lb. of cold water and 1 lb. of exhaust steam, assuming that the water is heated from 50 to 210 deg. F. in both cases. This is an important consideration, especially in condensing plants, where the supply of exhaust steam from the auxiliaries may be limited.

As a matter of fact, open heaters, in which the steam comes in direct contact with the water to be heated, will raise the temperature of the water to within 1 or 2 deg. F. of the exhaust steam temperature; on the other hand, closed heaters with 1/3 sq. ft. of heating surface per boiler-horsepower, the maximum amount of heating surface ordinarily installed will not heat the water to a temperature closer than from 15 to 30 deg. F. of the temperature of the exhaust steam, even when the surface is perfectly clean and the heater free from air binding. Accumulations of scale on the one side of the heating surface and grease or oil on the other cut down the rate of heat transmission from the steam to the water. Also, unless the heater has a large surplus of exhaust steam passing through it, air accumulates, blanketing and rendering inactive a part of the heating surface. The closed heater also does not provide for the elimination of the air and other gases driven off from the water by the heat as does the open heater. Recent researches have shown that the air in solution in the boiler feed water is the principal cause of corrosion in boilers and piping.

Simple draft gages indicate the difference in pressure between the point to which they are connected and the atmosphere. Differential draft gages indicate the difference in pressure between two points in the gas passages.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Protection of Electrical Equipment---II

PROTECTION OF TRANSFORMERS AGAINST HEATING OVERLOADS, INTERNAL SHORTS AND STATIC STRESSES. BY VICTOR H. TODD

IT IS BECAUSE of the great ease with which the voltage may be stepped up or down by means of the static transformer that the alternating current system has achieved such spectacular success. The transformer is one of the most reliable pieces of electrical apparatus and while it will stand considerable abuse, yet it appreciates good care by longer life and higher efficiency. The protection of transformers begins with the design of the transformer itself and the design of its location.

As in the generator, the limiting feature is the temperature which the insulation will stand safely; therefore, transformers must be protected against excessive temperatures. Poorly designed transformers are often subject to "hot pockets" or spots where the heat collects and thereby raises the temperature to a degree fatal to the insulation and causing a failure at this point. Just like a chain, a transformer is no stronger than its weakest link and such "hot spots" must be avoided.

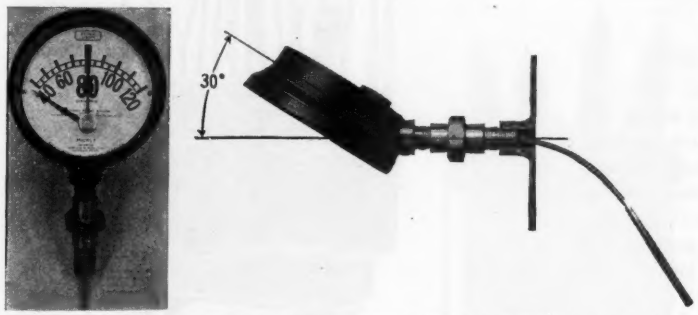


FIG. 1. THERMOMETER TEMPERATURE INDICATOR ON LARGE TRANSFORMER

FIG. 2. VIEW OF TRANSFORMER COIL WITH EMBEDDED EXPLORING COIL

Large transformers may be oil-cooled, water-cooled or air-cooled. In the oil-cooled, the whole transformer, coils and iron are immersed in a tank of oil. This oil carries the heat from the windings to the top of the tank where the oil is cooled and returns to the bottom of the tank to conduct away more heat. An oil-cooled transformer should not run above 85 deg. C. In the water-cooled type, this cooling of oil is assisted by large coiled pipes carrying water which conducts away the heat from the oil, and in this type the temperature should not run over 65 deg. C.

In the oil and water-cooled transformer the oil forms about one-half of the insulation strength of the transformer and the greatest enemy of this transformer is poor or wet oil. Protection is therefore obtained by periodic tests on samples of the oil taken sometimes as often as once a month and when the samples will not stand a specified disruptive test, the oil is drawn off, dehydrated and replaced. Tests have shown that even 0.1 per cent of moisture will cause a failure of oil insulation which shows the great importance of never allowing a drop of water to leak into a transformer containing oil as an insulation and cooling medium. Oil is considered in good condition when it will stand about 40,000 v. between disks ½ in. in diameter and 2/10 in. apart. This may be allowed to drop to 25,000 v. as a minimum after which the oil should be withdrawn, carefully dried and purified by special apparatus manufactured for this purpose. When filling transformers, strain the oil through a fine cloth to catch any solid foreign matter. Never use rubber tubing for filling, as this rubber contains sulphur which may be carried into the oil and attack the winding. Allow the oil to settle about 12 hr. and then see that it is up to the proper oil level.

Outdoor transformers are particularly subject to excess moisture unless operated at correct temperatures and care should be taken that the temperatures are maintained above ambient temperature even if it becomes necessary to supply extra heating coils in the bottom of the case. The temperature of outdoor transformers is often indicated on large thermometers which project above the transformer case and have their bulbs in the hot oil at the top of the transformer. Such a transformer indicator is shown in Fig. 1 in which it will be seen that the temperature may be easily read from a safe distance. Care must be taken that

the oil actually covers the thermometer bulb as there have been cases where low oil caused a low reading thermometer whereas the oil was actually very hot.

In the air-cooled type, the transformer is set over a large opening through which air is forced. Here, especially, much depends on the measures employed for cooling as well as the provision of fire-proof air ducts, and dampers to prevent the spread of fire once the transformer "blows up."

Blowers must be placed so that they supply only clean, pure, dry air and transformers must be placed so that no dirt or water may fall on them. Protection directly

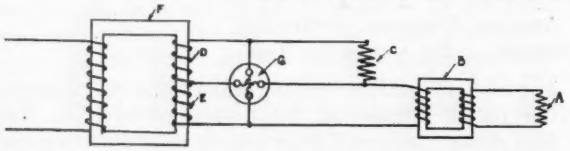


FIG. 3. A. C. TEMPERATURE INDICATOR SCHEME FOR TRANSFORMERS

against failure of water pumps or air blowers is not usually provided, as the transformer will continue to operate for some time without these cooling mediums and if the transformer is properly provided with protection from excess temperature, the failure of a pump or blower will be noticed and corrected long before it becomes necessary to shut down a transformer.

Temperature Measurement With Coils

Measurement of oil temperature, however, is not an absolute indication of the coil temperature and where it is desirable to work the transformer at its maximum capacity, then an indication must be had of the actual coil temperature, for it will be realized that there is a decided time lag between the heating of coil and heating of windings, while the oil temperature is partly due to the heat generated in the iron core and this does not vary with the load.

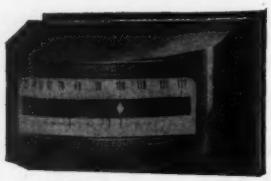


FIG. 4. THE A. C. TEMPERATURE INDICATOR

Embedded exploring coils with indicators and embedded thermo couples with potentiometers such as were fully described in a previous issue (page 1083, Nov. 1, 1923, issue) have been extensively employed but in the high tension transformers when the exploring coils or couples are properly insulated to provide safety, they are so far away from the main winding that the outfits are only of little more value than the oil thermometers. The solution lies in using an A. C. coil wound directly in the transformer winding and insulated from the instrument and operator by means of an instrument transformer. As will be evident from Fig. 2, this copper exploring coil is wound with only thin insulation from the main coil. This coil A is connected as in Fig. 3 to the secondary of a special transformer B, the primary of which forms one of the bridge arms, the adjacent one of which is a resistor C and the opposite two are D and E, which in turn form the secondary of a transformer F excited from any convenient low voltage source. The detector instrument G. is of the dynamometer type having the stationary coils excited directly from the voltage of D and E, while the moving coil takes the place of the galvanometer in the bridge. As in the d.c. type, when the resistance of exploring coil A is low, the bridge is unbalanced and the current flowing through the indicator causes it to indicate a low temperature. As the resistance (temperature) increases, the bridge finally balances, and then passing the balance point causes the indicator to indicate in the high direction.

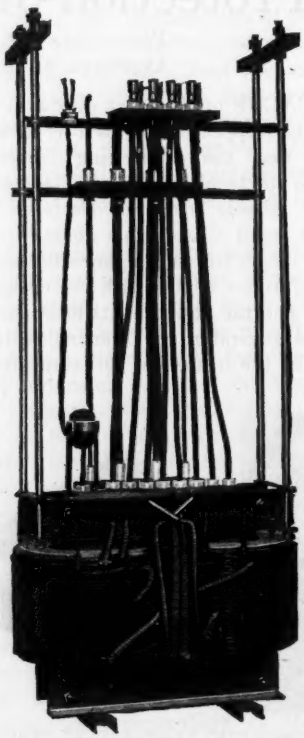


FIG. 5. SHOWING HOW THE CURRENT TRANSFORMER IS INSULATED AND THE LEADS BROUGHT OUT

Figure 4 shows a closer view of this indicator while Fig. 5 shows how transformer B is mounted and the leads brought out. Other refinements for safety and accuracy render this outfit an indispensable part of many well protected transformers.

The Artificial Hot Spot

Another method which has already proved its correctness through good operation is the artificial hot spot method where a miniature system or winding in the oil, having the same characteristics as the main transformer is heated by a current which is directly in proportion to the load current. Referring to Fig. 6, the current transformer, securely mounted inside the transformer case, is worked at the same iron and copper density as the main transformer and may be connected in the primary or secondary lead as desired. The secondary of this current transformer is connected to a heating coil located near the top of the oil.

In one case, the temperature is measured by the syphon type bulb thermometer of which a view is shown in Fig. 7. This indicator is provided with contacts which close a

direct current circuit on excess temperature and either sounds an alarm or trips the transformer out of the circuit.

This instrument is calibrated to read a temperature 10 deg. higher than the temperature as measured by the resistance of winding method and thus includes the correction for inaccessible hot spots as recommended by the A. I.

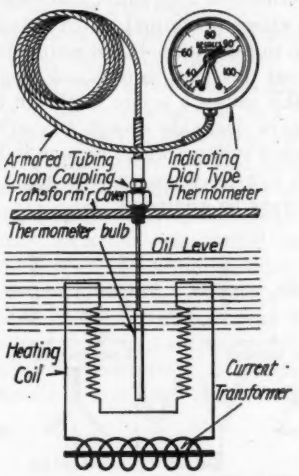


FIG. 6. SCHEMATIC DIAGRAM OF ARTIFICIAL HOT SPOT

In the smaller sizes, this is accomplished by ordinary fuses but in the larger types, circuit breakers are employed. As previously shown, the breaker should not open until the sustained value of short circuit current is reached and consequently the breakers are controlled by protective relays which allow a time delay of one or two seconds, during which time the "short" may clear itself when the relays

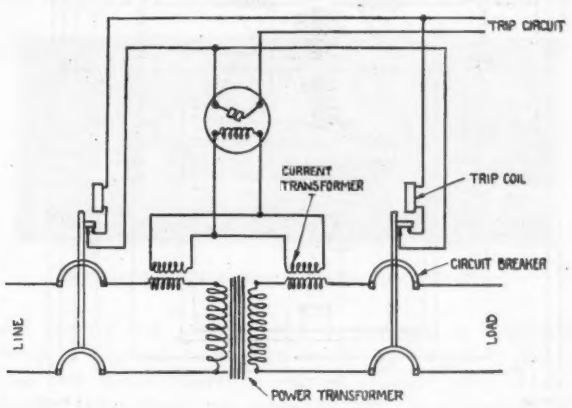


FIG. 10. PROTECTION FROM INTERNAL "SHORTS" BY THE DIFFERENTIALLY CONNECTED RELAY

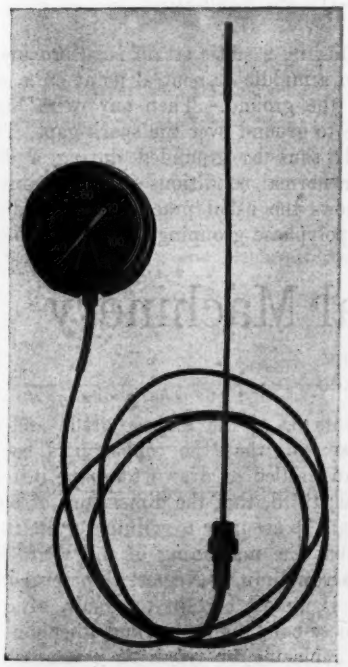


FIG. 7. VIEW OF THE DIAL TYPE THERMOMETER

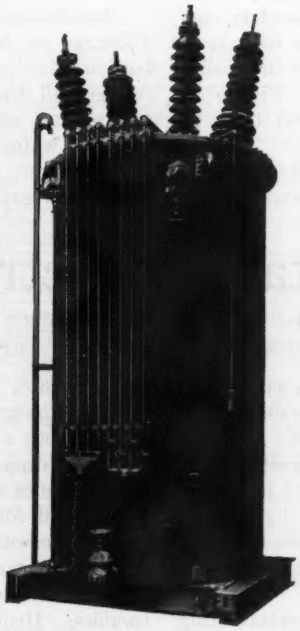


FIG. 8. LOCATION OF DIAL TYPE THERMOMETER ON LARGE TRANSFORMER

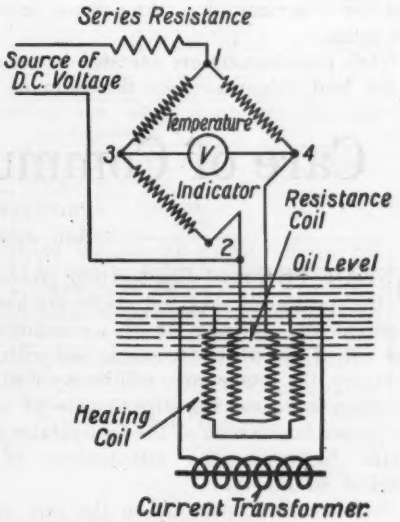


FIG. 9. ARTIFICIAL HOT SPOT WITH BRIDGE MEASUREMENT

E. E. Figure 8 shows the location of the dial type thermometer on a large power transformer.

In another type, the bridge arrangement as previously described is used with the scheme shown in Fig. 9, to measure the temperature of the artificial hot spot.

Protection From Overloads

While the temperature indicator may protect from long continued but moderate overloads, the transformer must be protected from line "shorts" or short time overloads of great intensity.

will reset, or the current may lower itself to a sustained value when the relays will trip the breaker.

Protection From Internal "Shorts"

A few turns short-circuited in a transformer may quickly ruin the entire winding. Often such defects will be noticed by smoke in an air-cooled transformer, which, of course, should be shut down at once and investigated. Protection from internal shorts is usually obtained by dif-

ferentially connected relays. As shown in Fig. 10, for a single transformer, there is a current transformer inserted in the primary and one in the secondary with their secondary both carrying the same current which normally circulates in the windings and does not pass through the relay. As soon as a "short" appears, the primary transformer will carry more current than the secondary transformer, thus causing an unbalance in their secondary currents which must pass through the relay. The relay is of the instantaneous trip type, as there is no object in causing a time delay when an internal short occurs. Figure 11 gives the diagrams of a three-phase protected bank in open delta.

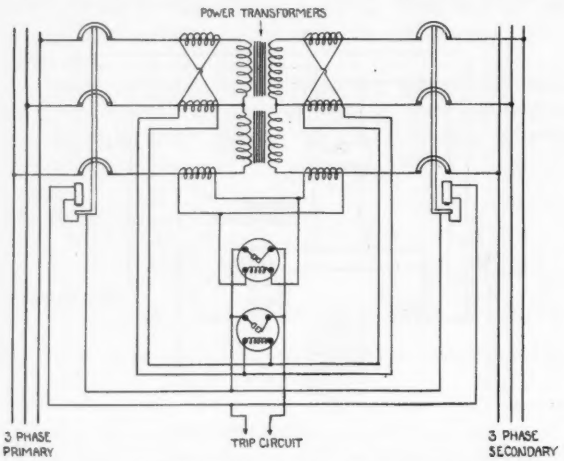


FIG. 11. A DIFFERENTIALLY CONNECTED SET OF RELAYS FOR PROTECTING A THREE-PHASE BANK

When transformers are operated in parallel, the relays on the load side may take the form of reverse power relays as an internal short circuit will cause an actual reversal of power feeding into the transformer from both primary and secondary thus quickly actuating the relays which isolate the transformer.

Static Stresses

With transformers of high ratio, there may occur potentials greatly in excess of normal which appear on the low tension side due to high tension line switching and surges. Protection against this may be obtained by grounding the secondary but this causes a severe strain on the insulation and is not always desirable except on very low tension lighting and power systems where anyone is likely to come in contact with a wire, when one secondary or a neutral point should always be grounded.

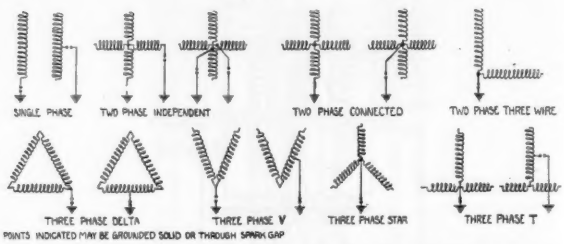


FIG. 12. USUAL PRACTICE IN GROUNDING LOW TENSION POLYPHASE WINDINGS

One method of relieving a static strain is to provide a discharge gap between a middle or neutral point on a low tension winding and the ground. Then any extra high voltage will discharge to ground over the spark gap. The low tension side will thus be grounded during a disturbance while under normal conditions it will be insulated. Figure 12 shows the usual practice in providing these spark gaps for polyphase groupings of transformers.

Care of Commutating Electrical Machinery

Pointers on a Time Worn Subject Which Are Justified, However, by Its Importance

ONE OF THE most disconcerting problems with which the operator of electrical machinery has to deal, is the temperamental misbehavior of a commutator. In nine cases out of ten where trouble is had with direct current machinery, the commutator will be involved and in a large percentage of cases, the direct cause of all the trouble. The proper functioning of the commutator is the most important factor in the maintenance of commutating electrical machinery.

Some excellent pointers on the care of commutating machinery were given by Burton E. James in a recent number of the Electric Journal, from which this article is abstracted.

Most of the ills to which a commutator may be subjected are evidenced by sparking or flashing. While these phenomena are extremely effective in announcing trouble, they give little information regarding the cause. The commutator is a sensitive element of the electrical machine, and in its present state of perfection is the result of years of experience. This experience has shown that often the slightest departure from correct methods of building results in an inferior product. A commutator which will give satisfactory service requires—first, that the mica segments be of the highest grade and of uniform thickness; second, that the copper bars be of homogeneous metal and rolled or drawn to shape instead of cast or drop-forged; third, that the dimensions of both bars and mica segments be accurate to within very narrow limits; and fourth that the machining of the V-grooves be accurate within narrow limits. Neglect to observe any of these precautions is almost certain to result, after a period of service, in loose bars, high mica, and other similar troubles. Hence in replacing or repairing commutators it is very important that the new parts be secured from a source where accurate dimensions, high grade materials, and proper assembly can be depended on—preferably from the manufacturer of the motor.

Various commutator troubles are enumerated and remedies suggested in the accompanying table. The most obvious ones are placed first and the obscure ones follow. If the difficulty is not obvious, the best procedure is to check each point in sequence until the trouble is located.

Grinding or Turning

Repairmen will have to use their judgment in determining the extent of repairs needed. If the commutator

is merely rough, turning or grinding will probably be all that is necessary, but if some of the bars are raised replacement may be required.

Commutators of small machines may be trued up most easily by placing the armature in a lathe and turning the face. Care must be taken to prevent dirt and dust from lodging in the armature windings.

Large commutators may be trued up without removing the armature from the frame by means of a grinding attachment fastened to a brush arm, as shown in Fig. 1. If the condition of the commutator is very bad, a turning tool should be used instead of the stones. A good turning speed is 150 ft. a min., while the best grinding speed is 100 to 120 per cent of the normal speed of the machine. All brushes should be lifted from the commutator during these operations. Extreme care should be exercised to prevent dirt and copper dust from entering the windings. This can best be accomplished by using a circular fullerboard shield cut to fit the commutator and fastened to the necks, and also by providing a suction system to carry the dust away. After this operation is complete the spaces between bars should be examined and all copper chips and dirt removed.

Undercutting

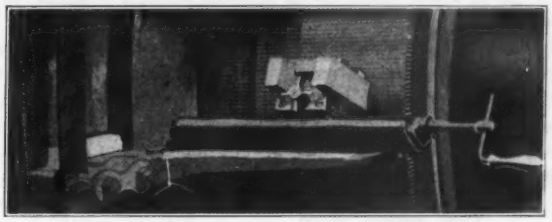
Commutators may be undercut by means of a power driven saw adapted to a lathe, a power driven saw guided by hand or a hack-saw blade mounted in a special holder. They should be undercut to a depth of 3/64 to $\frac{1}{16}$ in. All particles of mica and copper should be cleaned out of the slots. If the sharp edges of the copper bars are rounded off, better commutation will result.

Resetting Brushes

Perhaps the easiest method of resetting brushes on a non-commutating pole machine is to run the machine at rated load and shift the brushes until the position of best commutation is found. When a machine has commutating poles and adjustable brushes it should be run at rated load and the brush position found at which the speed is the same in both directions of rotation. On a reversing machine the brushes are usually non-adjustable and are generally set on the center line of the poles. If there is any doubt as to the correct position of the brushes, the manufacturer should be consulted.

Determination of Polarity

When field coils are replaced, the connections are often made improperly, which results in reversed polarity. This can be tested by energizing the field with a low current and testing the polarity with a compass or magnetic needle. Adjacent main poles should have opposite polarities and should therefore attract opposite ends of the needle. Care should be exercised that the magnetism of the needle is not reversed during the test. A commutating pole ahead of a main pole in the direction of rotation should have the same polarity as this main pole in the case of a motor; the reverse is true for a generator.



GRINDING DEVICE FOR TRUING COMMUTATORS

Evidence of Trouble	Cause of Trouble	Remedy
Sparking, flashing and blackened commutators	1—Roughened commutator	Turn or grind (See high and low bars)
	2—High mica	Undercut mica
	3—Brush sticking in box	Adjust poorly fitting brush; or remove dirt from the brush-holder
	4—Brush tension low	Adjust brush holder spring
	5—Poor grade of brush or improper application (Brush chatter)	Find out what brush manufacturer recommends
	6—Machine overloaded	Reduce load or install larger machine
	7—Brushes out of commutating zone	Reset brushes
	8—Reversed main or commutating pole polarity	Test with a compass
Pitted commutators (between bars)	Short-circuits between bars due to oil or dirt	Keep oil out of motor. Brush out foreign material between bars. Use commutator cement.
White powder coming from mica	Loose bars	Tighten commutator if possible, or renew bars and mica
High and low bars. Ends of bars raised.	Overspeed. Vibration. Dead bars. Soft copper. Heating. Short-circuits.	Replace individual bars or renew complete set of bars and mica
Broken bars	Aggravated condition of above	Replace individual bars or renew complete set of bars and mica

LIST OF COMMUTATOR TROUBLES

Tightening Commutators

It is important that commutators be kept tight. A good way to test for tightness is to tap the commutator with a hammer. If a dull sound instead of a ring is heard, trouble will probably develop, if it has not already done so. Another evidence of looseness is a white chalky substance sifting out from between bars. This is powdered mica caused by vibration of the bars and consequent chafing of the mica. This vibration may lead to fatigue cracks and ultimate failure of the bars. Small commutators are best tightened by putting the armature in a lathe and fitting a special wrench or key to the commutator nut or bolts, supporting the end of the wrench against the tail stock if necessary and screwing it up.

Replacing Bars and Segments

When a small number of bars are to be replaced, it is not necessary to remove the commutator from the shaft; but when the entire set of bars or the rear mica V-ring must be replaced, it will be necessary to press the commutator off the shaft. The leads may be removed from the commutator necks by driving a steel drift into the top of the slot and using a gouge to remove the filling piece and top leads, after which there is room enough to bend one side of the necks slightly and gouge out the lower leads. If solder is melted out with a blow torch several difficulties are apt to be encountered, such as annealing the hard drawn copper bars, injuring the insulation or getting solder into the windings. If the complete winding is to be renewed, the leads may be cut off back of the necks and the commutator reslotted.

After the leads are removed the commutator or armature should be placed on end with the commutator end up and the ring nut or bolts loosened. Each piece must be marked so that it can be replaced in its original position. After the metal and mica V-rings are lifted out the bars which are to be replaced should be tapped until loose and removed. If a new segment is to be inserted the old one can be lifted off the lower "V." New individual bars must be carefully filed to the exact shape of the bars they replace, or the repaired commutator will be worthless. Dirt and moisture must be kept out of the commutator while repairing. After the new parts are inserted, the metal and mica V-rings may be reinserted, and the nut or bolts brought up fairly tight. After heating the commutator to 120 deg. C. it should be given a final tightening while hot. The shipping band should be removed from a complete new set of bars and mica and the face trued up.

Soldering

Armature leads may be soldered into the commutator necks by means of a gas heated iron or in a solder pot. The latter is the most effective method but it is only practical where a large number of commutators are to be soldered. A good job of hand soldering can be done if care is taken. The armature should be slightly tilted toward the commutator end to prevent solder from running back of the necks and short circuiting the leads.

Brush Tension

Brush tension is best determined by means of a spring scale. The proper tension depends upon the service. Power and industrial apparatus should have the brushes under a tension of 2 to 3 lb. per sq. in.

Concrete Chimney to Serve Two Breechings

Brick Division Wall at Breeching Openings Carried on Reinforced Concrete Beam Placed Just Below These Openings. By C. W. Geiger

ON THE OPPOSITE page are shown the details of a reinforced concrete chimney of good design which has recently been constructed on the Pacific Coast. Its height is 150 ft. above the foundation and the internal diameter is 8 ft. 5 in. This is a chimney size that is common in engineering practice and in this particular design will be found many unusual features.

Stability of a chimney against overturning due to wind pressure is dependent upon the weight of the chimney, its lining and foundation, the area covered by the foundation and the nature of the soil upon which the foundation rests. The height of this chimney is about 5.4 times the width of the foundation as measured between opposite flats of the octagonal base. Reinforcement of the foundation consists of four courses of 1-in. sq. bars placed near the bottom. Each course consists of 36 bars spaced on 4-in. centers.

In the upper portion of the foundation slab are placed four courses of twenty-four ¾-in. reinforcement bars spaced on 6-in. centers. The concrete shell which forms the main body of the chimney is reinforced both circumferentially and longitudinally. The horizontal bars are the bottom of the chimney and on 12-in. centers at the top. Just above the breeching opening additional reinforcement is provided by spacing the horizontal bars on 4-in. centers. Additional vertical reinforcement is also provided at this point to direct the bending stresses away from the breeching openings which may readily prove to be the weak point in the chimney.

Vertical reinforcement consists of square bars, the first or lower courses of which are deeply imbedded in the foundation slab. At the base of the chimney these bars are 1 in. and ⅞ in. sq. while at the top they are ½ in. sq. Only one-third of the vertical bars are spliced at any one level, the method of making the splice being shown on the opposite page. The thickness of the concrete shell at the base is 15½ in. and the reinforcement is placed so that there is approximately 4½ in. of concrete between it and the outside of the shell. The shell is 5 in. thick at the top with the reinforcement located approximately 2 in. from the outside of the shell.

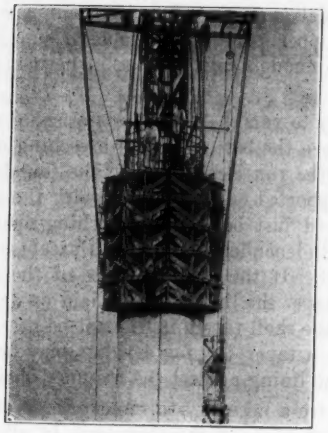
Concrete Beam Supports Division Wall

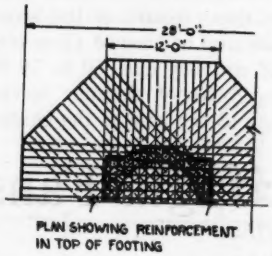
One feature of particular interest regarding this chimney is that there are two breeching openings, one located opposite the other. This meant that it was necessary to divide the chimney in two halves at this point. This was accomplished by placing a reinforced concrete beam on the diameter of the chimney and at an angle of about 45 deg. with respect to a line drawn through the center of each opening.

This beam was placed just below the breeching opening. An 8½-in. brick wall, with every other course a header, was built on this beam, the wall extending well above the top of the breeching openings. The lining extends for a distance of 70 ft. above the bottom of the breeching openings. This lining is of hollow tile set on edge in fire-clay mortar, this giving a lining 3 in. thick which is supported on a 3-in. off-set formed in the reinforced shell.

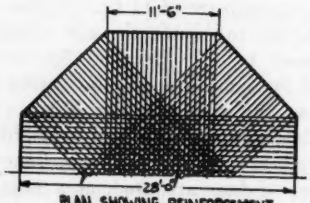
As the forms were removed the outside chimney surface was scraped and brushed to remove all form marks and then two coats of liquid stone cement were applied. The photographs reproduced on the opposite page show two methods for constructing and handling forms used in the building of concrete chimneys. The upper picture is that of a form made in five sections each 3 ft. high. Each section is made up of four segments to facilitate changing it from one position to another. The advantage of using five forms is that one section can be placed and poured each

Construction details of a reinforced concrete chimney

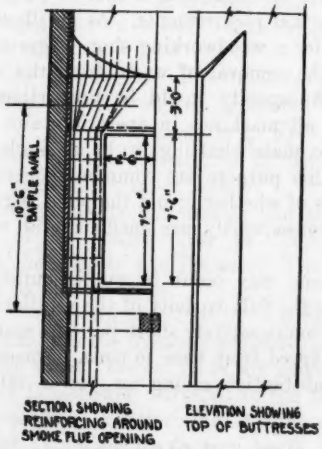




PLAN SHOWING REINFORCEMENT IN TOP OF FOOTING

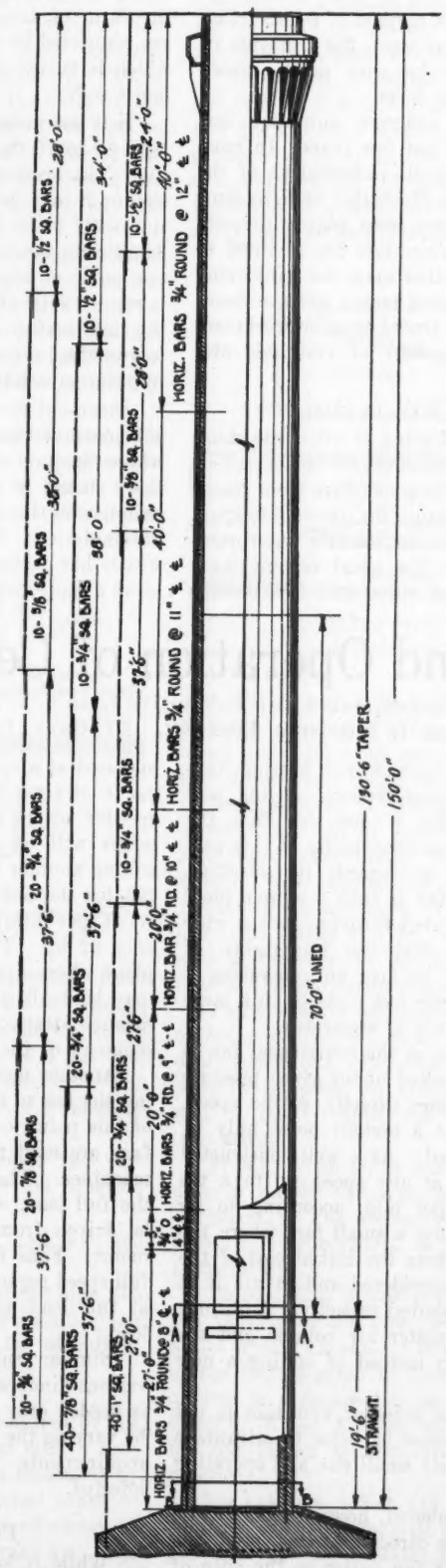


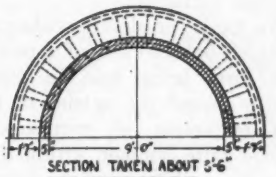
PLAN SHOWING REINFORCEMENT IN BOTTOM OF FOOTING



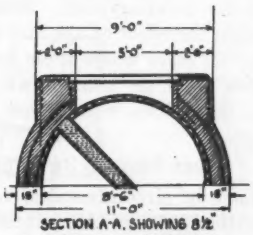
SECTION SHOWING REINFORCING AROUND SMOKE FLUE OPENING

ELEVATION SHOWING TOP OF BUTTRESSES

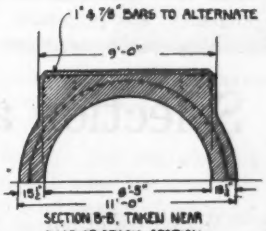

10-½" SQ. BARS 28'-0"
10-½" SQ. BARS 34'-0"
10-½" SQ. BARS 24'-0"
10-⅞" SQ. BARS 40'-0"
HORIZ. BARS ¾" ROUND @ 12" ℄ ℄
10-⅞" SQ. BARS 35'-0"
10-¾" SQ. BARS 28'-0"
10-¾" SQ. BARS 40'-0"
HORIZ. BARS ¾" ROUND @ 11" ℄ ℄
20-¾" SQ. BARS 37'-6"
20-¾" SQ. BARS 37'-6"
10-¾" SQ. BARS 37'-6"
HORIZ. BARS ¾" RD. @ 10" ℄ ℄
20-¾" SQ. BARS 37'-6"
HORIZ. BAR ¾" RD. @ 26'-0"
20-¾" SQ. BARS 27'-6"
HORIZ. BARS ¾" RD. @ 20'-0"
20-⅞" SQ. BARS 37'-6"
HORIZ. BARS ¾" RD. @ 8" ℄ ℄
40-⅞" SQ. BARS 37'-6"
40-1" SQ. BARS 27'-0"
HORIZ. BARS ¾" ROUND @ 8" ℄ ℄
130'-6" TAPER
150'-0"
70'-0" LINED
19'-6" STRAIGHT



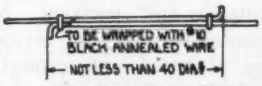
SECTION TAKEN ABOUT 5'-6" FROM THE TOP OF THE CHIMNEY



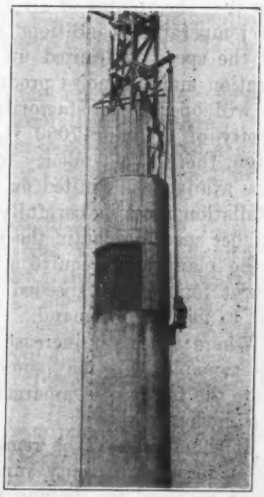
SECTION A-A, SHOWING 8½" DIVISION WALL. SECTION IS SYMMETRICAL ABOUT THE CENTER LINE



SECTION B-B, TAKEN NEAR BASE OF STACK. SECTION IS SYMMETRICAL ABOUT CENTER LINE



SHOWING METHOD OF LAPPING AND CLAMPING VERTICAL REINFORCING RODS



day so that about 4½ days elapses from the time a section is poured until it is removed, thus giving the concrete ample time to set. This method also allows the work to progress uniformly.

In the lower picture is shown a method of construction in which but two sets of forms are used, the segments of each form being held in place by wire cables drawn tightly around the outside of the form.

Construction of reinforced concrete chimneys has become quite common within the last few years. In most cases these chimneys have been built independent of the building in the same manner as is illustrated here, in some cases, however, the chimneys have been placed directly upon the building steel. Some engineers are inclined to question the effect of age and weather upon the reinforcing steel. In cases where there has been reason to have doubt on this point the trouble can be traced to poor workmanship, this alone will defeat the best of materials and design.

Steel Should Be Buried 2 in. in Concrete

Lack of circumferential reinforcing is often the cause of vertical cracks. All reinforcement should be covered by not less than 2 in. of concrete to keep moisture from reaching the steel which will rust and cause the concrete to spall. Chemical washes, because of their surface and waterproofing qualities, are preferable to the usual cement wash finish. Cast-iron copings are not often used for concrete chimneys, a good hard surface cement will be all that is required.

It is almost invariably the rule that concrete chimneys are provided with lightning protection. This usually takes the form of three platinum tipped copper points which are connected by a copper cable to a suitable ground plate which is buried deep enough so it will be in permanently moist soil.

It is not necessary to run the fire brick lining up more than 50 to 70 ft. above the bottom of the breeching opening. The brick may be run clear down to the foundation slab or it may be supported on a shelf cast with the shell, this shelf to be placed just below the breeching opening. The lining must be independent of the shell except at the one point of support. If the inside surface of the stack is run up without a taper the lining may be laid up against the shell surface, if the shell tapers it will not be necessary to run the lining on a taper. A few headers may be laid in order to steady the lining against the chimney shell.

Clean-out doors are a necessity to remove the soot and ash accumulation at the base of the chimney. In all cases where there is a space between the shell and the lining there should be clean-out doors located at the base of the chimney so this space may also be cleaned of soot and ash accumulation. A pile of chimney dust 50 to 70 ft. high which has settled during years of chimney service may exert a dangerous pressure at the base of the chimney.

Selection and Operation of Centrifugal Fans

Proportioning the Fan to Its Load is a Vital Factor in Securing Economy. By Chas. L. Hubbard

COMMON USE of fans in connection with heating, ventilation, mechanical draft, dust removal, drying, and other industrial processes, makes it desirable that the operating engineer have a good understanding of this part of his equipment, particularly as regards its selection, installation and operation. A fan is such a simple piece of mechanism and may be operated through such a wide range of speed and capacity that the importance of accuracy in proportioning it to its load and operating it to the best advantage is frequently lost sight of in a large plant containing many other kinds of apparatus.

Fundamentally, the principle of the centrifugal fan is such that the volume of air handled under given pressure and temperature conditions varies directly as the speed, and the speed is limited up to a certain point only by vibration and the noise produced. As a well constructed fan will operate satisfactorily at any speed up to a tip velocity of 6000 or 7000 ft. per min. according to its design, there is a tendency to use a small fan, where the space available is limited or where the initial cost of the installation must be carefully considered and to run it at a higher speed to obtain the required capacity. Additions to the plant may require a greater air volume and the present fan will be speeded up instead of adding a new unit to meet the demand.

Where a certain increase in noise or vibration is not objectionable, this may sometimes be done to advantage where the fan is of comparatively small size and operating at a moderate speed.

It should always be remembered, however, that while the increase in capacity varies directly as the speed, the power required for driving the fan varies as the cube of the speed. For example, suppose a 5-ft. diameter fan is operated at a speed of 200 r.p.m. and is delivering 42,000 cu. ft. of air with an expenditure of 11 hp. If the unit is speeded up to 400 r.p.m. to double the air volume, the power will be increased to $11 \times 2^3 = 88$ hp. while by adding another fan of the same size, or substituting a 7-ft. fan for the one in use, the same quantity of air (84,000 cu. ft. per min.) could be handled with an expenditure of only 22 hp. This fact is one of great importance in a plant where a number of fans are used, as a heavy load may be built up before one realizes it, which will overbalance strenuous efforts in other ways to improve the economy of the plant.

Another matter to be considered is that of proportioning the fan to the actual requirements. As an illustration of this point, consider a woodworking shop where exhaust fans are used for the removal of waste from the various machines. The fan capacity would be proportioned for the full load, with all machines in operation, and might be driven from the main shafting or by a single speed motor. Fans for this purpose are commonly operated at full speed regardless of whether or not the plant is running at full load and consequently are inefficient at reduced load.

Similar conditions may occur in public buildings of various kinds where the full capacity of the ventilating fan is needed only for comparatively short periods, and where by varying the fan speed from time to time, to meet actual requirements, a substantial saving in power might be affected.

Principles of Fan Operation

While it is not important for the engineer to be able to design a fan, he should be familiar with its action

under various conditions and should understand the relations existing between pressure, velocity, resistance and temperature, as these factors have a decided bearing on the selection and operation. The different kinds of pressure used or measured in determining the action of a fan are known as *dynamic, static* and *velocity* pressures, and are commonly expressed in inches of water column. Dynamic pressure is due solely to air movement. Static pressure is that which is exerted against the sides of the duct, in a direction perpendicular to them. It has no relation to the movement of the air, but is due to the resistance of the system of piping. Partially closing the end of a short duct connected with a fan outlet will produce the same result.

Dynamic pressure indicates a force tending to drive the air through the duct, while static pressure, on the other hand, indicates a resistance or force opposed to this. The excess of dynamic pressure over static pressure is the velocity pressure which represents the force available for accelerating the air from a state of rest and maintaining its flow through the pipe.

Velocity pressure, in inches of water, may be found by subtracting the static pressure, as indicated on a piezometer gage Fig. 1A, from the dynamic pressure, as shown on a Pitot tube gage Fig. 1B. By making a connection from

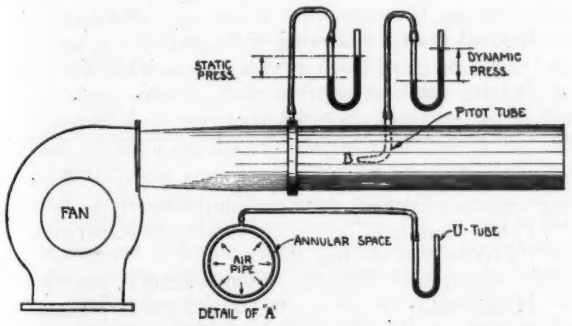


FIG. 1. EQUIPMENT USED FOR FAN TESTING

a piezometer ring to one leg of a U tube and from a Pitot tube to the other, the U tube will indicate the differential or velocity pressure direct. The arrangement shown in Fig. 2 illustrates a common combination of Pitot and piezometer tubes for measuring velocity pressures. The inclined gage shown is used where the pressure differential is not great.

Having determined the velocity pressure, the corresponding velocity may be computed from the equation

$$V = 66.75 \sqrt{VP}$$

in which V is the velocity, in ft. per sec. and VP, the velocity pressure, in in. of water.

Knowing the average velocity and area of the pipe, the volume of air moved may be found by multiplying together the velocity and the area. The air hp. or output, is given by the equation

$$\text{hp.} = \text{DP.} \times \text{C} \div 6.356$$

in which DP. is the dynamic pressure, as measured by the Pitot tube and C, the cu. ft. of air moved per min.

Brake horsepower delivered to the fan is measured by a dynamometer, or determined by the electrical input to the motor (knowing its friction load). The efficiency of the fan is then the air hp. divided by the brake hp. The capacity at which the highest efficiency is found is taken as the most economical rating, and the fan should be operated near this capacity for the best results.

For each different pressure there is a certain air quantity which the fan will deliver with its best efficiency, and there is a certain speed at which it should run. It will deliver more or less air against the same resistance but not with the same efficiency and not at the same speed.

Suppose it is desired to deliver 86,000 cu. ft. of air per min. to a building where the resistance of the heater and ducts is such that it is necessary to maintain a static pressure of ⅜ in. at the fan outlet. What should be the size, and speed of fan, and hp. of the motor for driving it. Referring to a manufacturer's table of characteristics for a 5-ft. fan, we find it must operate at a speed of 173 r.p.m.

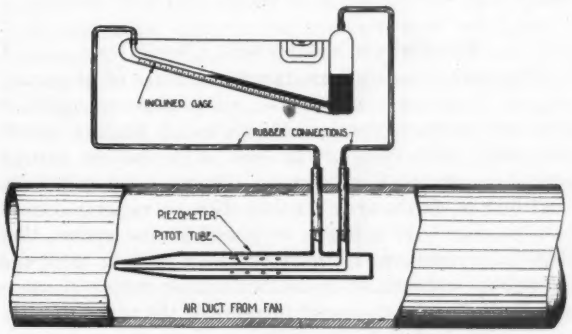


FIG. 2. COMBINED PITOT TUBE AND PIEZOMETER WITH DIFFERENTIAL INCLINED GAGE

and will require a 25.4-hp. motor. We find also that a 6-ft. fan, running at 117 r.p.m. will move the same volume of air under the same pressure conditions with an expenditure of only 16.4 hp., a saving of 9 hp. In selecting a fan for any given set of conditions, the available space, initial expense and cost of operation should be taken into consideration, remembering that a larger fan at a lower tip velocity will require less power for moving the same volume of air against a given resistance. In the present case, this saving of 9 hp. would soon make up the difference in first cost of the fan to say nothing of the lower first cost of the smaller motor.

Fan tables are commonly prepared for air temperatures of 65 to 70 deg. F., hence are not applicable to induced draft conditions. In order to make the necessary corrections for adapting the ordinary fan table to the conditions met in induced draft, the following facts must be taken into account.

First: When air is heated and expands, the weight of a given volume varies as the absolute temperature.

Second: The necessary fan speed to produce a given pressure is proportional to the square root of the absolute temperature.

Third: The power required to drive a fan varies as the velocity of air flow, when the pressure and area of outlet remain constant. Without going into the derivation of the factors given in Table I, we may state that when applied to ordinary fan tables, based on air temperatures of 60 to 70 deg. F., they will give approximate corrections for the higher temperatures involved in induced draft practice.

For example, a 5-ft. fan (from manufacturer's tables) running at 194 r.p.m. will discharge 93,340 cu. ft. of air per min. against a static pressure of 0.50 in. of water and will require 34.2 hp. If applied to induced draft,

where it is desired to maintain the same static pressure, handling chimney gases at a temperature of 500 deg. F., it would be necessary to run the fan at $194 \times 1.35 = 263$ r.p.m., with an expenditure of $34.2 \times 1.35 = 46$ hp. The

TABLE I. CORRECTION FACTORS FOR INDUCED DRAFT FANS

Temperature of gases	Factor for volume	Factor for speed	Factor for horsepower
400 deg.	0.77	1.28	1.28
500 deg.	0.73	1.35	1.35
600 deg.	0.70	1.42	1.46

air drawn into the ash pit at a temperature of 60 to 70 deg. will be $93.340 \times 0.73 = 68.138$ cu. ft. per min.

Resistances and Outlet Velocities

Fan data given in manufacturer's tables of characteristics is based on a maintained static pressure which is measured at the outlet in a blow through heating system or forced draft system. In case of a suction heating system or induced draft system, it is measured at the fan inlet and is shown by a static suction or vacuum instead of a pressure. If a fan is so placed in the system that there is a resistance to the flow of air at both inlet and outlet, the maintained resistance against which it operates is the sum of the static pressure at the outlet and the static suction at the inlet.

In selecting a fan for a new installation it is impossible to measure the resistances against which it is to operate, and it is customary to assume a resistance or pressure based upon average results found by tests made in similar buildings. While these will necessarily vary considerably, the figures given in Table II may be taken as a fair average.

It should be noted that the pressures given for forced draft are for ordinary conditions, and that certain forms of under-feed stokers require considerably higher pressures, running up to from 3 to 5 in. in some cases.

For heating and ventilating work, the best outlet velocity to employ will depend largely upon the type of building; figures commonly used are approximately as follows:

Public buildings.....1,200 to 1,800 ft. per min.
Factories and drying installation .....1,800 to 2,200 ft. per min.
Forced draft .....2,800 to 3,400 ft. per min.
Induced draft .....3,000 to 3,800 ft. per min.

TABLE II. AVERAGE RESISTANCE ENCOUNTERED IN VARIOUS TYPES OF CONSTRUCTION

Type of building or class of work:	Static Pressure in. of water
Public building, without heaters or washers	0.25 to 0.50
Public building, with heaters, but without washers	0.50 to 0.75
Public building, with heaters and washers	0.75 to 1.00
Minimum resistance for factory systems	1.00
Ordinary resistance for factory and round house systems	1.25
Maximum resistance for factory and round house systems	1.50
Low-pressure drying	0.75 to 1.00
Ordinary resistance for forced draft with semi-bituminous coal	0.75
Ordinary resistance for forced-draft with low grade run-of-mine bituminous	1.00
Ordinary resistance for forced-draft with slack and screenings	1.25
	Static Suction
Induced draft for burning 18 lb. of coal per sq. ft. of grate per hr.	0.75
Induced draft for burning 25 lb. of coal per sq. ft. of grate per hr.	1.125
Induced draft for burning 40 lb. of coal per sq. ft. of grate per hr.	1.50

Economy in the Use of Fuel

Data Collected from Papers and Discussions at the Conference of Engineers Held in Philadelphia On January 15. Presented By P. E. Shaver

UNTIL recently economical use of fuels has not been seriously considered by consumers generally. Our country has always been rich in fuels, especially coal, but due to the great increase in cost of coal, the question of economizing is being considered by consumers and engineers to a great extent. There have been rapid strides made in recent years in the design and development of fuel saving devices and besides these devices there is always the question of properly applying and operating them.

This question of fuel economy was recently discussed from many angles at a meeting of engineers held at the Engineers' Club of Philadelphia and the purpose of this article is to point out some of the important phases of this question as discussed there.

Fuel Economy Through Interconnection

By the interconnection of power systems a great fuel saving can be brought about, by distributing loads to most economically operated stations and having power on lines at places and times when most needed, at such times as heavy traffic periods. Also by interconnection, great power resources can be brought together and redistributed to great advantage and saving. Large stations can be built near the source of supply of fuels and these stations feed into high voltage lines. This system has also the advantage of continuity of service, proper co-ordination, ability to use different kinds of fuel, etc.

Economy Through Power Surveys

One of the most important phases of economizing fuel is the surveying and studying of sources of supply of fuel and the resources of different sections. This was brought out by Morris L. Cooke, chairman of the Pennsylvania Giant-Power Survey, in a paper before the Conference. He explained that this survey was organized at the beginning of Governor Pinchot's administration for the purpose of studying the resources of the State and making recommendations for power projects needing action, the using of Pennsylvania water power and to have an interstate

connection between New York and Pennsylvania, the introduction in State Legislature of bills pertaining to issuing permits, the condemning of lands for public use, leasing of lands and waters and other bills to develop power projects.

Five counties in the western part of the State, Mr. Cooke stated, contain coal sufficient to develop power equivalent to that of Niagara Falls for five hundred years, and therefore, the water power resources of the State are a secondary consideration. He also dwelt on the great service and economy of fuels that could be derived from the interconnection of the different power systems throughout the State. Because of the great value and economy of bringing together these resources and redistributing them to better advantage, he recommended the pooling of energy. It is the purpose of the survey to establish several large stations of about 650,000 hp. These stations are to be at or near the fuel supply when condensing water is available and will feed their current into a 220,000-v. transmission system, connections being made for redistribution of the current to small users and country districts. It is proposed to use the byproduct resources and thereby attain a great fuel saving by the recovery of 44,000,000 T. now in Pennsylvania which has not been processed.

Into all of these superpower and interconnection systems enters the necessary high cost of transmission and interconnecting lines which must preclude any reduction in power production costs measured at the consumer's end of the line but this is thought to be a further proof that we should have more power surveys such as Mr. Cooke described to study the possibilities of these systems for the purpose of bringing about substantial economies in the use of fuels.

N. G. Reinicker, of the Pennsylvania Power and Light Co., of Allentown, Pa., described how his company has linked together different power systems to great advantage and fuel saving and pointed out some of the advantages of an interconnected system, such as: Continuity of service, improved service, proper co-ordination, tremendous economy of fuels by the interconnected system, loads can be distributed to most economically operated stations and thereby reduce cost, different types of fuel can be used and high class supervision can be employed.

He stated that such a system should have a co-ordination department to schedule and dispatch service, have full power to order equipment put into service and give orders to operating personnel.

Co-ordination between industrial and public service plants was urged by V. L. Sanderson, emphasis being laid on economy obtained through the proper consideration of waste steam. He made an appeal to take care of the "steam falls" as well as the water falls to conserve fuel. Much fuel, he stated, can be saved and more efficient operation attained by an interconnection between these plants and the lines of the public utility companies.

Automatic Control of Boilers

In a paper on boiler plants, T. A. Peebles dwelt on efficiencies in stations and said that there should be wider use of control devices and higher class training in their use. By the proper application of control devices, from 5 to 20 per cent of the losses can be saved. Each type of boiler plant should accomplish a definite efficiency. This comes nearer being realized in the large plant than in the small one, due principally to the greater attention paid to the station's operation.

Automatic devices are not installed to replace the fireman but to perform some of the functions that can be better accomplished automatically than by hand. Automatic control can make boilers respond immediately to changes in load, can give correct proportion of fuel and air to the furnace, control the air pressure in accordance with the resistance of the fuel bed but it cannot remove clinkers from the side walls. The fireman must adjust conditions to take care of changes in the quality of coal, changes in the moisture content of the fuel, holes in the fire and other conditions which cannot be definitely predicted. Automatic control can, however, do a lot toward correcting these conditions. A change of 5 or 6 per cent in the moisture content of the fuel may cause a stoker to feed 10 per cent more coal for the same speed. With automatic control, the operator does not have to worry about the change in load on the boiler but can give his attention to minor adjustments to keep the plant up to the highest efficiency.

F. F. Coffin stated that too many executives were careless in the solving of fuel saving problems. They give much time and thought to study of tonnages of output, overhead expenses, etc., but they give little time to the conservation of fuel in their plants, proper firing and handling of coal, steam waste, air leaks and proper kind of coal for their particular use. As a remedy he suggested wider use of CO_2 recorders, pyrometers and other instruments to aid the fireman in securing higher efficiency. He appealed to engineering clubs and power journals to spread propaganda to get executives interested in such methods of economizing.

This thought was further discussed by Hugh J. Freyn, consulting engineer of Chicago, who said the people of Europe through necessity are studying the saving of fuel (referred to as heat unit chasers). He cited one case, which he has investigated, in which a plant has a department consisting of a chief engineer, reporting to the president, and under his command are five mechanical engineers and fifteen mechanics and laborers, all of their time being given to the study of fuel economy and the cost of maintaining the organization was only 2 per cent of the total saving caused by it.

Powdered coal was discussed by H. D. Savage and a paper was submitted by R. G. Galt. Mr. Savage said that the burning of powdered coal is true economy and its growing demand is sufficient proof of its economy. One of the reasons why it is coming into greater use is the fact that lower grade of coal can be used, also there is no combustible matter left in the ash and that fuel oil can be burned in powdered coal furnaces as well as the coal itself. In regard to the percentage of ash discharged from the chimneys which is sometimes objected to, Mr. Savage stated that he has made actual tests and found that the percentage is actually so small that there cannot be any possible serious objection to this.

Regardless of what fuel saving apparatus is employed or what kind of fuel is used, real economy can be obtained only through better education and scientific study of the many questions involved in the utilization of fuels. Throughout the meeting, the trend of thought was for better education along these lines. The keeping and preserving of records so that what results are obtained for efforts spent to save fuel can be determined necessitates accurate bookkeeping and real fuel economy cannot be had without the co-operation of the executives financially responsible for the operation of the plant.

THE INQUIRING ENGINEER

The Inquiry

At this time of the year there is usually some thought given to the question of central heating by power plant engineers engaged in central station work. The fundamental problem before the house is usually the effect of the sale of central station heat on the economy of operation in a plant which is designed primarily for the purpose of supplying electrical energy to its customers. Under what conditions will the proposition of supplying central heat be profitable?

Replies

J. H. WALKER, Superintendent of Central Heating,
The Detroit Edison Co., Detroit, Mich.

For the warming of buildings, the idea of utilizing the heat now wasted to the atmosphere or to the condensing water in electrical generating plants often presents a strong appeal to the operators of such plants. From a purely thermal standpoint the proposition is obviously sound as it means the salvaging for a useful purpose of a great amount of heat and the consequent conservation of an equivalent amount of coal. There are, however, certain commercial considerations which affect the success of such a project.

The underlying obstacle to the success of central heating enterprises is, broadly speaking, the close competition offered by the isolated heating plant. A building owner will surely purchase his gas and his water supply and usually his electricity from an outside source, but in the case of his heat supply the relative simplicity of the process of producing it upon his own premises, at perhaps as low a cost, often impels him to operate his own boiler plant.

Many ventures in the central heating field have been unsuccessful because of failure to foresee the development which has taken place and is still proceeding in the electrical industry. Small plants whose exhaust steam was used for heating have been absorbed by large power systems and their generating units shut down and the enforced continuation of the heating service on a live steam basis has been disastrous. Central heating should not be undertaken from a generating plant which may under any probable future conditions be robbed of its electrical load.

Consideration must be given to the nature and permanence of the district which it is proposed to serve. A residential district, because of its scattered load, may require an investment in underground construction out of all proportion to the amount of steam which could be sold. Furthermore, the growth of some of our cities has witnessed the deterioration of high class residential districts to the extent that the service is no longer in demand by the present residents.

I believe that the following fundamental conditions are necessary to the permanent success of a central heating enterprise using exhaust steam.

1. Permanence of the supply of exhaust steam if the business is established on that basis.
2. Density of load.
3. Permanence of character of the district heated.
4. Proper relation of the hourly electrical and heating loads so that little or no live steam need be used.
5. A generous differential between the retail and wholesale prices of coal.

There is a legitimate field for central heating service and a growing appreciation on the part of the public of its advantages. In the business districts of our more prosperous cities where the space occupied by the boiler plant and the item of attendance have a measurable value, the building owner is often anxious to secure the service and willing to pay its true cost. Changing standards, which make necessities of those things which once were luxuries, have caused the public to become more appreciative of the intangible advantages of the service—its convenience, reliability and cleanliness—and this appreciation will undoubtedly increase in the future.

R. D. DEWOLF, Chief Operating Engineer,
Rochester Gas and Electric Corp., Rochester, N. Y.

Of the two great needs of modern civilization, heat and power, the supplying of heat, while a far older industry than the supplying of electric power, has not been developed on the large scale to which our electric systems have grown, primarily because it is much easier for the individual to supply himself with heat than it is to supply himself with electricity. The amount of investment required by the individual for heating himself is small, and up to comparatively recently the economies which can be effected through the use of purchased heat, to say nothing of its convenience, have been little appreciated.

From the standpoint of the electric generating company, the furnishing of steam for industrial or heating purposes is not really a matter of vital importance until we get into the class of consumers whose establishments are of sufficient size so that they could operate their own plants without excessive investment and labor charges. The electric generating company, then, finds itself in competition with the isolated plant and must be able either to give the consumer a complete substitute for the consumer's isolated plant or else furnish electricity at such a low rate that it will be cheaper for the consumer to supply himself with steam for heating and industrial processes and buy the current from the central station company, than to operate his own plant. With steam gen-

erated electrical energy, it is generally necessary to furnish the consumer a combined service.

The first problem before the central station heating manager is to see that his rates are right and that he can demonstrate to the consumer that the service justifies these rates. It is evident that the cost of furnishing such service will vary over a wide range, consequently the rates will vary proportionately. Among the principal factors entering into this must be mentioned the amount of business available per foot of distributing system, the gross amount of business handled by the meter, and the losses between the steam generating station and the consumer.

In the combination of the heating business with the electric business, there are, generally speaking, three stages of this combination:

A. Financial only: that is, the same interests own both companies, but outside possibly common directors, there is no inter-relation between the companies.

B. Common management, where the heating company becomes a department of the parent company although there is no physical combination of the plants or other fixed assets.

C. Common management and physical combination of the plants and other fixed assets.

Cases A and B need little discussion. For Case C, however, I would like to point out certain advantages which can be obtained where conditions permit of the actual physical combination of the plants.

In considering the advantages of combination, we must first study the difference between the load curves of an electric power load and of a steam heating load. The factory has to be heated up prior to the arrival of the workers. Thus, the steam heat load comes on earlier than the industrial power load, though it synchronizes more or less with the electric railway load. The factory building having once attained 70 deg. temperature, the demand for heating steam drops off, although the power load continues at its normal demand.

It is thus evident that by a combination of these loads on the same boiler plant, due to the fact that the maximum peaks do not occur at the same time, the boiler capacity required will be appreciably less than that required for two separate plants not physically combined.

In addition, a certain amount of the boiler capacity required for the heating load can be used quite effectively to replace banked boiler capacity normally required to be available for use as standby for the electric load in case of a sudden abnormal demand. Due to the heat storage capacity of the buildings supplied with steam for heating purposes, in case such an abnormal demand is placed upon the electric power generating capacity, the amount of steam being delivered to the heating system can be reduced at least 50 per cent for a period of from 15 min. to half an hour without materially affecting the temperature in the buildings. In cases where actual physical combination of the plants has been effected, this steam can be diverted from its normal use for heating and used in the main condensing turbines for electric generation, where it will be used to its maximum generating capacity.

Quite frequently, by superimposing the steam heating load on the electric generating load, the load factor on the boiler room can be made materially better than the load factor on the electric generating plant to which the boiler room is furnishing steam. Each case of this kind must be studied on its own merits. The ideal situation would be one in which through the combination of these loads the boiler would normally be operating at or near the point of maximum efficiency, say 150 per cent of rating. With an overload capacity of 250 per cent of rating, the overload capacity above 150 per cent would be available for carrying the peak loads on the electric system and the long hour operation at 150 per cent of rating would result in a materially better overall plant efficiency which would benefit both the steam and electric operation.

Where a plant is especially designed to carry a combined load of this character, it can be built at a materially lower cost than would be the cost of two separate plants. Individual units in the plant could be made larger and hence more economical in their operation. With larger investment, the labor operating cost per unit of output could be lowered. Burning larger amounts of coal, one would be warranted in the installation of coal handling equipment not warranted in the case of a smaller plant.

Experience shows that in the case of a steam distributing system of considerable size, the daily load factor will run quite high during the colder months of the year. Where a combined plant is used, this gives a much desired method of filling in the night valley in the load curve.

With a rate system based on actual costs, there should be no question about the advisability of combining the electric and heating loads when the heating load is of such a character as to combine with the electric load to advantage and where the investment in the distributing system is not excessive.

D. S. Boyden, Supt. Steam Heating Service Dept., The Edison Electric Illuminating Co., of Boston.

Today we find central heating plants employed in practically all large public and privately owned institutions, railroad terminals and industrial properties. In many of these cases the central plant was installed to replace a number of small isolated plants at a great expense for investment and replacement.

Operating results of these plants have repeatedly proven the wisdom of the undertaking and today in all similar developments the central heating plant is a matter of prime importance. This practice is universally accepted as sound and profitable and is analogous to district heating conducted as an independent business for profit.

The district heating business has a distinct advantage in that it may select the area in which it will supply its steam and fix the prices which shall be charged. That failures may have occurred in district heating systems does not indicate that central heating can not be made to pay but that logical areas, conservative estimates, suitable rates and adequate financing are necessary. The fundamental advantage of district heating is certainty of service and convenience and it is not necessary that the cost of this service compete with the actual operating cost of the isolated plant.

Undoubtedly the profitable distribution of heat from central plants will become more general. Other influences that must be taken into account are the differential in the cost of fuel between the price paid by the heating company and that paid by the small consumer and the reduction in fire insurance rates for the consumer.

I am of the opinion that district heating systems of modern design in properly selected areas which are efficiently operated and which sell steam upon a measured basis with reasonable rates are certain to yield a fair and reasonable return upon the invested capital.

Pulverized Fuel Makes Good Showing

TESTS GIVE HIGH CAPACITY, HIGH EFFICIENCY, LOW UPKEEP AND LOW COST OF BANKING. COMPARISON OF THREE AND FOUR-PASS BAFFLING. EFFECT OF CO_2 PERCENTAGE ON STACK TEMPERATURE

IN A PAPER presented before the Engineer's Society of Western Pennsylvania and the discussion which followed, much interesting information was given as to the requirements for burning pulverized fuel, advantages from its use and results from a series of operating tests made by J. C. Hobbs, manager of the Allegheny County Steam Heating Co. and L. W. Heller, general superintendent of power stations of the Duquesne Light Co.

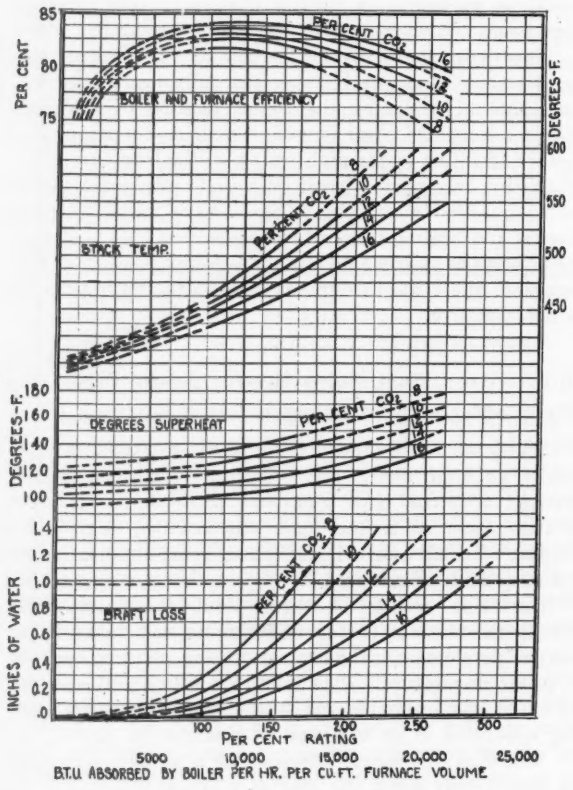


FIG. 1. RESULTS OF TESTS ON BOILER WITH FOUR-PASS BAFFLE USING PULVERIZED FUEL

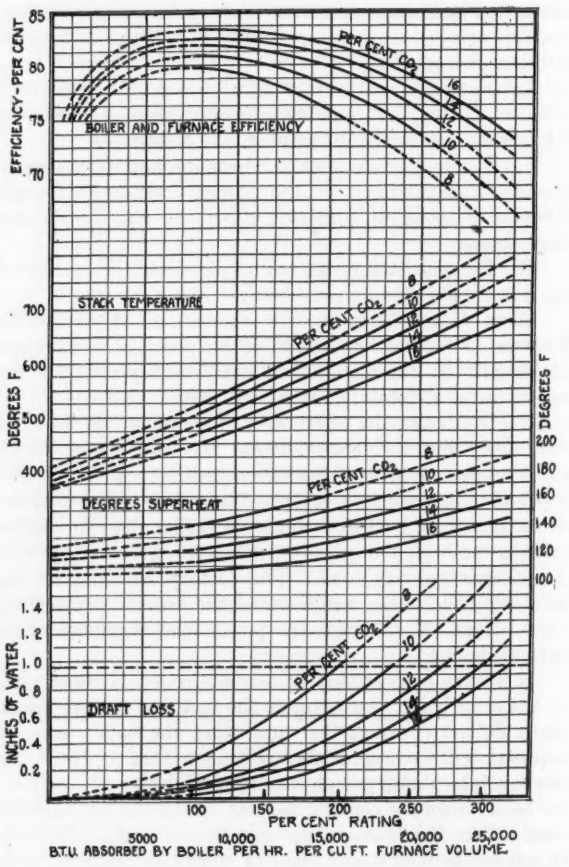


FIG. 2. TEST RESULTS FROM BOILER HAVING THREE-PASS BAFFLE

For the tests a Stirling boiler was used, having rating of 822 hp. to which was added 180 sq. ft. of surface in the water screen at the bottom of the furnace, giving a total of 840 hp. The boiler was equipped with a B. & W. superheater having 255 sq. ft. of surface, which was later replaced by one with 1031 sq. ft. The boiler was tested with three-pass and with four-pass baffling, the results being shown in the figures herewith. It developed up to 2500 hp. during the tests.

As difficulties encountered in operating boilers at high capacities, Mr. Hobbs enumerated: Keeping down the excess air, preventing the loss of combustible in the ash, avoiding excessive upkeep, cost of furnace, removal of ash and clinker from the furnace, prevention of radiation loss, reducing loss from coating of heating surfaces with ash and clinker deposits, reducing tube failures due to high temperature. The ideal sought is to burn all the coal, transfer all the heat to the steam and run the plant at a low maintenance cost.

Powdered fuel meets these difficulties in the following ways. The best materials for resisting high temperatures can be used, no metal coming to the surface of the furnace but steel framing being used to give strength, protected from the heat by lining of refractory material and with the walls cooled by air and water currents. Air is intimately mixed with the fuel so that a minimum can be used, yet secure complete combustion. Such ash as is deposited can be cooled so that it will appear as a fine dust, easily removed. Radiation is reduced by the air cooling, and the heat carried back to the furnace. By means of long flame travel, the gases are thoroughly mixed so that there is no zone of intense heat among the tubes.

In the three-pass baffling, each pass was over one bank of the tubes. In the four-pass, two rows of tubes of the first bank were placed below the first baffle to absorb heat by radiation; the rest of the first bank, the superheater and the first row of the second bank were in the first pass; the second pass was over the tubes of the second bank; the third pass over the last row of tubes in the sec-

ond bank and the first two rows of the third bank and the fourth pass over the remaining tubes of the third bank.

Results of the tests are given in the curves, Figs. 1 and 2. These show the variation of efficiency, stack temperature and degrees of superheat with per cent of rated load delivered and for different values of CO_2, also draft loss for various values of CO_2. From these last it is possible to study the effect of CO_2 on draft loss for a given power delivered, the showing being that it is possible to get greater boiler capacities with the same stack and baffle arrangement simply by reducing the excess air. The relation between boiler rating and CO_2 with a draft loss of 0.98 in. is shown for the two kinds of baffling in Fig. 3.

Power used for the pulverizing and feeding system is shown in Fig. 4. The mill was a 6-ton, 6-roll Raymond taking practically constant power at all capacities for each ton of coal handled. Power per ton for the feeder decreased slightly as the quantity handled increased, while power per ton for the blower decreased materially as the coal handled increased.

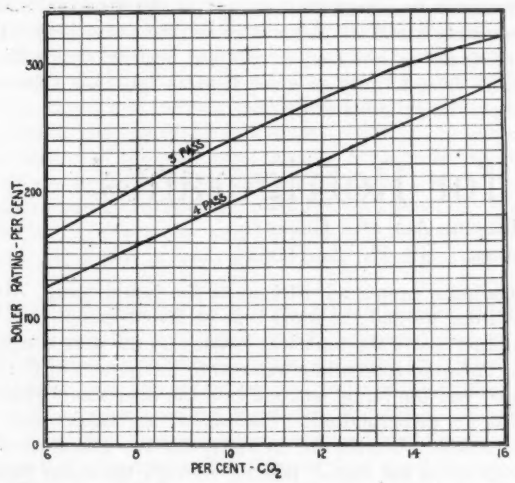


FIG. 3. VARIATION IN MAXIMUM BOILER RATING FOR THREE AND FOUR-PASS BOILERS HAVING MAXIMUM AVAILABLE DRAFT LOSS OF 0.98 IN. FOR DIFFERENT PERCENTAGES OF CO_2 IN THE FLUE GAS

Mr. Hobbs gave as the conclusions of the authors that, for large boilers to be operated under central station conditions; powdered fuel gives advantages in increased boiler capacity, increased stack capacity, increase in the sustained boiler efficiency, decrease in the fuel required to hold the boiler banked, increase in the efficiency of combustion, ease of sealing the boiler during banked periods, reduction of the number of banked hours due to the ability to start up a boiler quickly, reduction of the cost of furnace maintenance under high-power operation.

Commenting on the paper, W. C. Buell, Jr., of Pittsburgh, figured that the furnace had been designed for development of 9400 B.t.u. per cu. ft. per hr. at 100 per cent rating of the boiler, or for 24,500 B.t.u. per cu. ft. per hr. at 250 per cent of rating. Mr. Buell, in his design of furnaces for liquid fuels, has provided for a development of 28,800 B.t.u. per cu. ft. per hr., with an allowable maximum of 36,000 B.t.u. for periods not over 2 hr. and has never had a case of failure of linings, without the use of air-cooled walls. As flame temperatures and excess air supply are about the same for oil and for powdered coal, he felt that the furnace volumes provided were excessive.

In providing stacks for oil-fired boilers, Mr. Buell has always divided Kent's capacity figures by 2 and has always found that he had ample capacity.

Discussing the gains from the use of powdered coal, Henry Kreisinger said that the reason that higher efficiency and capacity are possible is because the coal can be completely burned with much less excess of air. Instead of having to use from 25 to 105 per cent excess, as is often done when burning solid fuel, pulverized fuel can be burned with from 10 to 25 per cent, thus cutting down chimney losses and getting higher furnace temperatures.

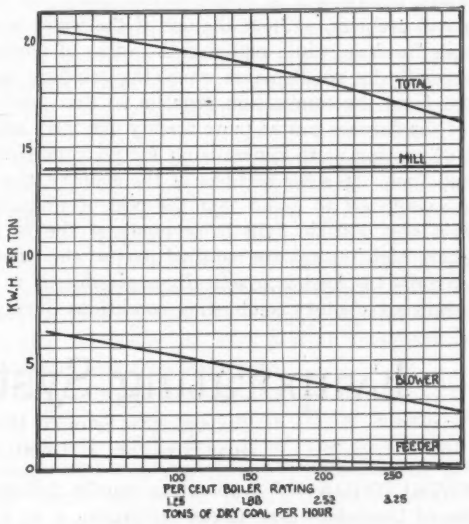


FIG. 4. POWER CONSUMPTION OF PULVERIZED COAL BOILER PLANT

This higher temperature brings in the two problems of ash disposal and endurance of furnace linings. The water screen at the bottom of the furnace seems to solve the first problem and the air cooling of the walls the second.

The walls should be kept so cool that the slag-forming ash freezes before it strikes the walls, for, if the slag forms on the walls to any great thickness, it will run down and be troublesome.

Describing the installation at the Lykens plant of the M. A. Hanna Co., C. F. Herington stated that it was a 6600-hp. plant in 12 units. The coal is lifted 400 ft. in a single lift from a pool, is stored, dried to less than 1 per cent moisture, pulverized, moved by drag and screw conveyors some 200 ft. and delivered to a 36-T. storage over the boilers.

The air pressure used for feeding is 2 to 4 in., about 50 per cent of the air needed coming in with the fuel. The combustion chamber is 21 ft. deep, the flame being directed downward and arranged so that it can be slanted toward the front or rear walls to melt off any slag that may accumulate. The chamber is 4 ft. 6 in. wide at the bottom and 12 ft. wide at the top, the boiler being 16 ft. 6. in. wide. Sides of the chamber are sloped 45 deg., water being flushed over them to carry dust and ash to the sewer.

Average monthly efficiency is 81 per cent. It takes 29.81 kw.-hr. per ton of dust to prepare the coal and 22.8 kw.-hr. per ton for grinding. The fuel is ground to pass 80 per cent through a 200-mesh screen, the composition

being moisture 0.46 per cent, volatile 7.5 per cent, fixed carbon 69.6 per cent, ash 20.2 per cent, heat value 11,700 B.t.u. per pound.

Edward Rahm, Jr., stated that he preferred to admit the air to the combustion chamber at a low velocity, admitting nearly all the air required with the fuel. He felt that the solid wall was probably preferable on account of lower first cost and maintenance and with low air velocities had had no trouble in upkeep. He felt that there would be less draft loss and better control of the air in proportion to the fuel, if the air came for the most part, with the fuel. He thought that, if radiant element superheaters are used in the walls, the ash will be cooled so that there will be no ash removal problem, without the use of the water screen.

Joseph Breslove, while realizing the value of powdered fuel, especially for small plants where the grinding can be separated from the combustion problem so that good efficiency of the furnace can be more readily obtained, uttered a word of caution as to generalizing for all conditions of plant and fuel. In some sections of the country, the fuel may be so difficult to grind that the cost of preparation will offset any possible gain in economy of the furnace. Also, where high ratings are required part of the time and at other times the load is practically negligible, it is hard to maintain satisfactory combustion conditions during the light load periods, in the big combustion chamber required for the high rating loads, a condition not so pronounced with stoker firing.

A. E. Blake called attention to the advantage of grinding the fuel finer for smaller plants thus giving better chance for complete combustion in a small setting where the flame must be short.

Mr. Hobbs stated that too much radiant heat absorbing surface would undoubtedly affect the efficiency and possibly the operation. He thought that the walls should be water cooled, the interior walls consisting of fire brick refractories or of slag so that the furnace temperature can be maintained. Small boilers can be used without water or air cooling of the walls both because an excess of air is used and because the temperature is kept down by radiation to the boilers or elsewhere.

In the Duquesne plant, the fuel was ground to pass 60 per cent through a 200-mesh screen, but for smaller plants the coal should be finer.

Air cooling of the walls replaces the possibility of using economizers to take more heat out of the stack gases and it seemed to him a simpler way to use the excess heat. The water screen is, however, an efficient heating device for it absorbs several times as much heat as the same tube surface put into the boiler proper.

Evaporating Systems for Refrigerants*

Evaporators Should Have in a Measure All the General Qualities of a Good Steam Boiler. By W. F. Davis[1]

CONSTRUCTION OF evaporators usually follows the line of laboratory experiment equipment, i. e., a long continuous coil of pipe. In most instances those coils are in multiple and connected to headers, this being particularly true for ice tank construction. The early type evaporator, called an expansion coil, consists of coils that are fed with refrigerant at one end and the vapor taken off at the other end. The advantage of this construction is that foreign substances, such as water, or oil, which do not adhere to the walls, will pass through the coil and out with the vapor.

Another evaporator, which is an improvement over the preceding type, is known as the top-feed and top-suction type. It is made by connecting the bottom ends of two vertical stands of series coils with the two top ends connected into the liquid and suction headers respectively. This arrangement somewhat relieves the liability of the compressor receiving a slug of liquid but there is a greater tendency for the compressor to receive superheated gas. One of the oldest types of evaporators is the horizontal coil, which is usually built of 2-in. pipe and placed so as to extend across the ice tank, or ceiling of a room, each layer or section being fed by a separate liquid valve. In ice tank construction both headers are on top, or outside.

About 15 yr. ago, the flooded systems were placed upon the market. One scheme provided a liquid header at the bottom of the ice tank, fed by one valve, and the top ends of the vertical coils were connected into the suction header at the top. The suction having a large container set in the vertical line with a double gage glass, which was used as a guide for setting the feed valve. This type helped the operation but the gas at the compressor would be either too wet, or too dry, on account of its being almost impossible to maintain proper adjustment of the liquid feed. About that time, we had the same type of layout except that the container above the tank was larger and acted as a separator. A liquid return line was run to the bottom of the coil header and the liquid was fed into the separator (which is called an accumulator). Feeding of the liquid into the accumulator obviated the necessity for the gas, formed in refrigerating the liquid, passing through the many feet of continuous coil.

Next came the flooded evaporator which was bottom fed with the suction header at the top connected into a low set separator from which the suction was taken. The liquid for the evaporator was first passed through a coil located within this accumulator. This was done for two reasons, first, to evaporate the slop-over from the evaporator and second, to cool the liquid. This arrangement conserves the slop-over and is an insurance against a slug of liquor going to the compressor.

Separators Keep Liquor Out of Compressor

All of these types of apparatus showed but very little progress and a first real step forward was not made until the introduction of the evaporator known as the shell type cooler. In this type, a separator is used to keep the liquor out of the compressor or accumulator and a return drain pipe is provided for the separated liquor. The shell-type cooler resembles the return-tubular steam boiler, except that provisions for circulation and separation of vapor from refrigerants are usually neglected. It is so full of tubes that those at the top have a tendency to superheat the vapor, unless an excess of liquid is fed. It has the same advantage, however, as the double-pipe brine cooler, namely that of rapid movement of flow of circulating media.

Double-pipe brine coolers have many advantages but when connected up, counter currents have a tendency to

*Abstracted from a paper read before the National Association of Practical Refrigerating Engineers, at Memphis, Tenn.

[1] Chief engineer, Lilly Ice Cream Co., Memphis, Tenn.

superheat the gas. These coolers may become overflooded for the reason that it is hard to regulate the feed when operating at full capacity and efficiency.

When a refrigerant is released into a container of low pressure, it first contracts in volume as its temperature is reduced by the boiling off of a portion of the liquid. Second, the liquid continues to boil as heat flows to the liquid and the heat is carried off by the vapor. In the process of releasing a gaseous liquid of relatively low boiling temperature into a container of less pressure, there is caused an evaporation of a part of the liquid in reducing its temperature to a point corresponding to the pressure within the container. Upon reducing the pressure by removing part of the vapor or gas from an evaporator, the process of ebullition will begin and continue so long as the vapor is being removed and heat is supplied. Discontinue the removal of the vapor and the liquid will cease boiling as soon as the temperature becomes relatively equal to that corresponding to the pressure on the liquid.

In the same measure as a furnace is considered a generator of CO_2 gas or a boiler as a generator of steam, the low pressure side of a refrigerating apparatus may be considered a generator of vapor. Evaporators should have in a measure all the qualities of a good steaming boiler, namely, rapid and unrestricted circulation of the liquid refrigerant, the liquid in full contact with the entire exposed surface of the evaporator, ample provision for separation of the liquid from its vapor, arrangement so that the generated vapor will acquire little if any superheat, automatic feed of the liquid and provision for separating out oil and water that may be precipitated in the evaporator.

Liquid Feed Should be Automatically Controlled

In general, the evaporator should be constructed so as to afford rapid unrestricted circulation, with the liquid in full contact with the entire exposed walls of the tubes, or shell. The vapor opening should be so located and protected that there will be no entrainment of liquid, nor superheat of the vapor and the liquid feed should be automatically controlled.

Unrestricted and facilitated circulation will either increase the capacity of the apparatus, or it will reduce the temperature range between the boiling liquid refrigerant and the body that is giving up its heat, thereby causing greater efficiency. The liquid being in full contact with the entire circumference and length of the tubes will result in greater efficiency.

If the manufacturer, or the engineer, were advised to generate steam for a prime mover by placing a continuous coil in a furnace, with the water feed connected to one end, and the other end connected to the steam chest of the engine, he would immediately put the adviser down for a layman but it often happens that liquid refrigerant is fed into one end of a coil and the operator is expected to regulate the feed so as to have neither a slug of liquid nor superheated gas go over to the compressor.

When different temperatures are carried, as in cold storage, the evaporators should be in several units which can be cut out or in at will. When it is necessary to allow the temperature to rise, the feed can be cut down so that only the effect of superheating the vapor will cause the refrigerant to become gas. The evaporator within the fire-cooler should have the same advantage as the ice freezing tank evaporator. Room evaporators will best be placed in a bunker space, so as to secure the benefit of convection, due to rapid and free air circulation. Wall evaporators can be designed so as to have all the internal advantages of those in freezing and cooling baths and bunkers.

Thermometers Should Be Placed in Suction Lines

In adjusting liquid feed valve, it will not do to judge adjustment by the frost on the suction pipe. Judging the setting of feed valves by the frost on the return pipe is more or less guess work, because pipes will frost when the suction gas is at a temperature below 32 deg. F. Superheat or liquid in the suction gas is not desirable and there may be either when valve setting is judged by the frost. When pressure gages and mercury wells with thermometers are placed in the suction lines at the evaporators there will be no guess work in adjusting the feed. If the pressure is say 15 lb. gage in the evaporator we note from the ammonia tables that the liquid is 0 deg. F. The gas leaving the evaporator should not be more than 1 or 2 deg. higher.

In efficient operation, the forecooler and liquid cooler evaporator should be connected in multiple with the tank evaporator and should be fed liquor in the same manner as all other evaporators. Every evaporating system should have a means of purifying the refrigerant where the recovery apparatus is the compression system. Purification can best be accomplished by using a separator on each suction line branch or on each suction line between the nearest branch and the compressor.

An accumulator corresponding to the receiver type separator for a steam engine should be located at the compressor. It will sidetrack or precipitate any free refrigerant, oil, water, or other foreign matter, prevent slugs of liquid refrigerant passing into the compressor, precipitate any scale carried by the vapor and it will also prevent free liquid passing into the compressor.

Many plants have a great pressure loss between the evaporators and the compressor cylinders. A plant checked during the past season was found to have a drop in pressure of 18 per cent between the ice tank evaporator and the compressor manifold. A further drop of 18 per cent was found between a point just above the manifold junction and the suction pressure within the cylinders. A receiver type of separator placed just above and connected to the suction valve located on top of the manifold reduced the drop in the suction line pressure from 18 per cent to 7 per cent.

One of the most common faults with centrifugal pump installations is the practice of allowing short, sharp turns, elbows, fittings and other air pockets in the suction lines. No air pockets should be allowed in the suction line of a centrifugal pump, for the reason that air is bound to collect in such pockets and destroy the suction vacuum. Angles should consist of long sweep elbows, or pipe bends, preferably the latter. Valves and other fittings should be omitted and the run should be as straight as possible.

Efficiency of the dollar is the final basis upon which to judge the value of a coal. An analysis will often reveal that a low priced coal which gives 65 per cent efficiency will prove more economical than a higher priced coal which gives 75 per cent efficiency. A loss in efficiency due to a gain in capacity may make for economy by saving fixed charges on additional equipment.

Overcoming Forced Draft Difficulties

ONE OF the boiler houses at our plant is an 8000-hp. plant in which steam is generated at a pressure of 180 lb. in 8 Stirling four-pass units, rated at 1000 hp. each.

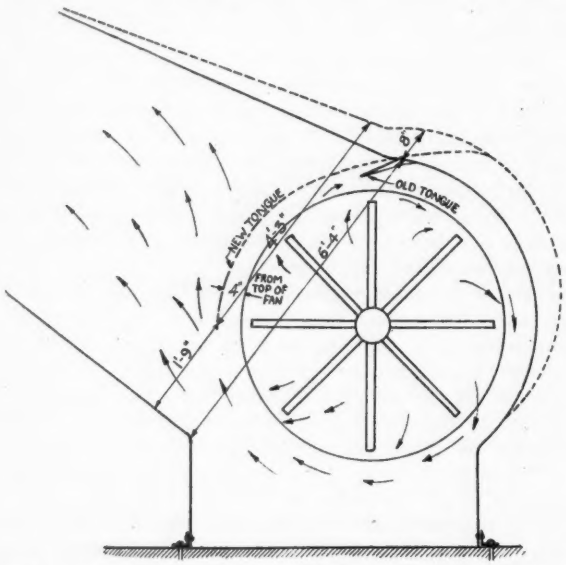


FIG. 1. NEW TONGUE AND LARGER HOUSING IMPROVED THE FAN OPERATION

Each boiler is fitted with 2 Coxe chain grate stokers each having an effective grate area of 131 sq. ft., i. e. 262 sq. ft. of grate surface for each boiler. Forced draft is supplied to the grates by eight fans, one for each unit. Each boiler economizer together with the forced and induced draft fans form a complete unit; there is no common wind duct.

The forced draft fans gave us considerable trouble, due to the fact that they would draw air in on one side of the suction and throw out part of it on the opposite side, causing a constant jarring of the entire unit and a constant wide fluctuation of pressure. Never were we able to maintain more than 2 in. water pressure. As these fans are rated at 35,000 cu. ft. of air pressure per min. at 3½ in. water pressure, we naturally wanted to get all that was coming to us.

We tried various ideas without success until finally we installed an extra large tongue, raising the housing as shown in Fig. 1. The dotted lines show the changes that were made; the full lines show the original shape of housing. Figure 2 shows a record of the air pressure before the changes were made. Notice the wide variation of pressure. Figure 3 shows a record of the air pressure after the installation of the larger tongue and new housing. The dampers are opened and closed at will, and the unit runs at the normal speed of 443 r.p.m. Figure 4 shows the air pressure after speed was cut down 57 r.p.m. It will be noticed that we are getting a much better air supply with the unit running at reduced speed since the improvement than we were getting under the old conditions with units running full speed. The machinery runs much more smoothly also due to the stopping of this trouble. The saving in steam consumption is considerable.

Philadelphia, Pa. WM. J. MCGURK.

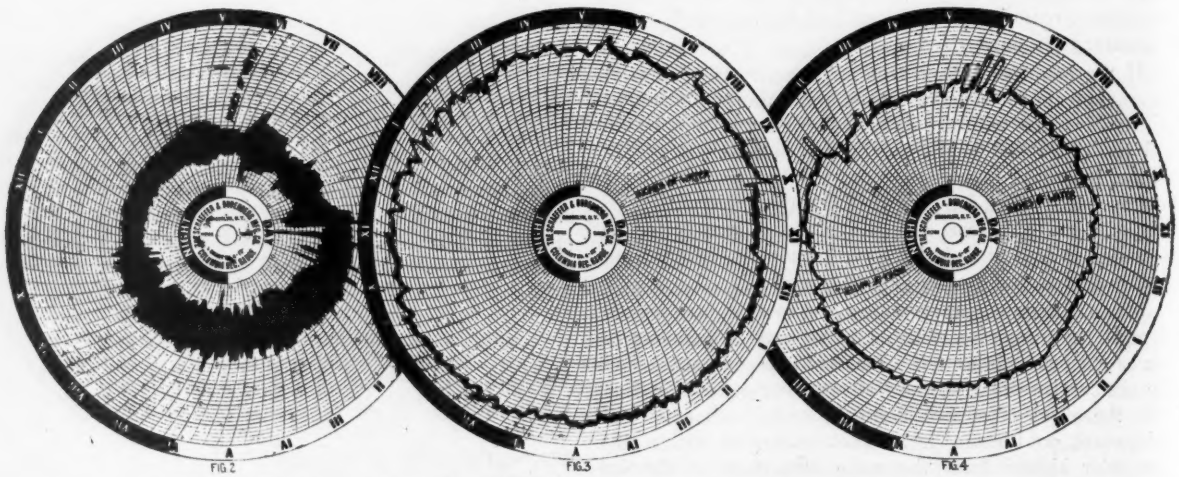


FIG. 2. PRESSURE VARIED WIDELY BEFORE THE CHANGE WAS MADE. FIG. 3. PRESSURE VARIATIONS DUE TO FAN CHARACTERISTICS WERE PRACTICALLY ELIMINATED. FIG. 4. THE DESIRED PRESSURE AND DELIVERY WAS OBTAINED WITH A MATERIAL SPEED REDUCTION

Boiler Installation Economy

NOT LONG ago in a Wisconsin city, the board of education put up a new building and the question came up as to what should be done about the disposition of the boilers in the group. The new and larger school building had been built adjacent to an old building. A new boiler plant having sufficient capacity for the combined buildings was installed in the new building. The two horizontal return-tubular boilers in the old building were no longer needed.

For convenience let us designate this combination of buildings as "AB" and a building hereafter mentioned as "C."

Two horizontal return-tubular boilers in building "C" were too small for the load they were intended to carry. It was decided that they should be replaced by two larger boilers. The two surplus boilers in building "AB" were large enough to replace the boilers in building "C." The problem resolved itself into whether the old boilers should be moved and installed, or whether new boilers should be purchased and installed. The old boilers had been 18 yr. in service. The consensus of opinion of many was that it would be a foolish waste to spend money installing the old boilers, however, the school officials wanted something more thorough than off-hand opinions, so a careful analysis was made.

The point I wish to emphasize is the importance of considering the interest on an investment. It should be noted that $2400 is the estimated difference between the cost of a new and the cost of an old installation. This difference might have to be borrowed at 6 or 7 per cent or if not borrowed, it would be invested at the same rate.

I have assumed that the average life of boilers receiving good care is 30 yr., although I know of boilers that have been in service over 40 yr. and are still in good condition.

Cost of buying and installing two new boilers $4400.00
Cost of moving and installing two old boilers 2000.00
Estimated life of new boilers..... 30 yr.
Estimated life of old boilers..... 12 yr.

Neglecting upkeep:

Yearly depreciation of new boilers..... $146.66
Yearly depreciation of old boilers..... 166.66

These depreciation figures were obtained by dividing $4400 by 30 and $2000 by 12. Maintenance of brickwork, pipes, fittings, and such items were neglected, because they would be new in each case. Repairs to boiler shells were not considered owing to the excellent condition of the old boilers.

Difference old and new installations..... $2400

This $2400 could be invested at 6 per cent before applying it to the probable new installation at the end of 12 yr., the assumed life of the old installation. In this case, however, it is possible that building "C" will be obsolete in 12 or 15 yr. and then torn down. The boilers should easily last until that time.

Interest at 6 per cent on $2400 compounded annually for 12 yr..... $2434.34
Depreciation on new installation 12 yr.... 1759.92
Depreciation on old installation 12 yr.... 2000.00

Add the $2434.34 interest which would not have been earned if the new boilers had been installed, to the sum $1759.92 representing 12 yr. depreciation on the new installation.

$2434.34 + $1759.92 = $4194.26.

This is the real depreciation of the new installation for 12 yr. as compared with the $2000 depreciation of the old installation. The saving amounts to $2194.26.

Looking at it from another angle: Assume that the board had $4400 to spend in a new boiler installation. However, instead of so doing, they spent $2000 to install the old boilers on hand. They then invested the difference, $2400 for 12 yr. at 6 per cent. At the end of 12 yr. this sum would have more than doubled itself by increasing to $4834.34. With this money they could install new boilers and have $434.34 left over, thus having had the use of the old boilers for 12 yr. for practically nothing.

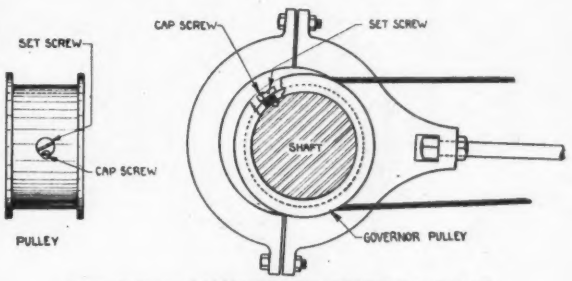
I shall leave it to the reader to imagine what action the Board of Education took in regard to the boilers.

I hope my critics will be a little indulgent for my neglecting a few points that really would have made but little difference in the solution of the problem.

W. H. FITTUS.

Securing a Governor Pulley

ON A LARGE Corliss engine, the set-screws in the governor pulley persisted in working loose, and were a constant annoyance. They were recessed ¾ in. into the shaft. The heads of the screws were 1¼ in. diameter, ½ in. thick, and shouldered in a counterbore in the face of the pulley.



METHOD OF HOLDING SET SCREW IN PLACE

A hole for a ½-in. cap-screw was drilled and tapped, half in the set-screw and half in the face of the pulley as shown in the sketch. After the cap-screw had been screwed in tight, it was marked then taken out, sawed off and a slot cut for a screwdriver. When replaced and tightened down there was no more trouble with the set-screw working loose.

M. M. BROWN.

Faulty Drier Operation

WE HAVE some machines in our plant which are used for drying cotton. The drips from these machines used to discharge into a cast-iron drum or receiver, thence to a return trap which fed direct to the boilers. After a while the trap was taken out and the discharge from the receiver was piped to an open feed-water heater through a 1¼-in. line. This system was fed direct from the boilers at 100 lb. pressure.

Occasionally it was found that the cotton did not dry properly. When this happened the operator would open a 1-in. valve from the receiver to atmosphere with the result that the drying effect was increased. Later a trap was put on this line and although the system was kept free from condensate, the cotton would not dry as it should, yet for years these same driers were trapped directly back to the boilers with good results. What is the reason for the present condition?

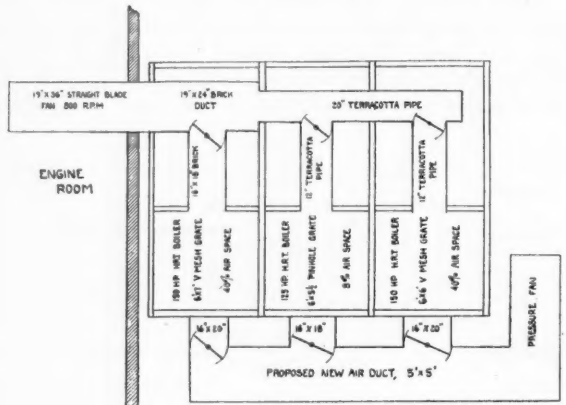
M. W. C.

QUESTIONS AND ANSWERS

Is the Fan at Fault?

IN OUR plant we have a battery of three boilers, two having a capacity of 150 hp. each, and one, 125 hp., under which we burn rice coal containing about 30 per cent sand. To burn this fuel we employ a forced draft fan, located in the engine room adjacent, from which air is delivered through a duct under the boiler settings to the ash pits, as shown in the accompanying sketch.

This arrangement is giving us poor results and we are trying to find a better system. Would a pressure fan



LAYOUT OF FORCED DRAFT FAN AND DUCT INSTALLATION

placed in the engine room over the old duct furnish sufficient air to burn this fuel satisfactorily or would it be advisable to build a new duct under the firing aisle and place the new fan there as indicated in the sketch?

Grate dimensions and percentage of fire area are shown on the sketch. P. D.

Remodeling Refrigerating System

WE HAVE in operation in our plant one old two-cylinder, single-acting, 7 by 10-in. ammonia compressor which is belt driven at 60 r.p.m. from a 20-hp. induction motor. This unit is used on a direct expansion system serving an ice tank containing twenty-four 100-lb. cans and a storage room 15 ft. long by 6 ft. wide by 8 ft. high in which the temperature is maintained at from 40 to 45 deg. F.

Will it be advisable from the point of view of economy, efficiency or ease of operation to change the present direct expansion system in the storage room to a brine circulating system? The present location of this storage room is extremely undesirable but the circumstances are such that it is not feasible to move it. As this is a hospital the use of direct expansion in the main building is undesirable as any leakage constitutes a source of danger to patients. It is for these reasons that a change is contemplated if such a change is desirable.

1. What size and how many feet of pipe will be required for the brine coils, to hold a temperature of 40 deg. F.?

2. What size brine cooler should be used?

3. Will one brine tank large enough to take care of twenty more 100-lb. ice cans be sufficient to supply the storage room when both are operated at the same time?

4. Will the present compressor be large enough for the additional load?

5. What size pump and motor should be used to circulate the brine?

6. How should the brine coils be connected? In series or in parallel?

7. What kind of insulation should be used on the brine pipes to the storage room? They run out of doors for a distance of 172 ft.

8. What material should be used for the brine coils?

C. J. R.

Proportioning Heating Costs

WHAT CHARGE should be made against heating in a plant having 30,000 sq. ft. of direct heating surface and 10,000 sq. ft. of indirect? Coal costs $7.50 per short T., delivered to the boiler room floor and the ash removal costs $0.10 per T. of coal. Energy for the fans for the indirect heating system costs $0.03 per kw.-hr.

How should the cost of steam per 1000 lb. at 100 lb. and at 2 lb. pressure, be figured, including insurance, depreciation and rental charges? J. W. C.

Steam Consumption of Drier

WE HAVE in our plant a drying room which is heated by two banks of coils, 6 pipes high and 20 ft. long, made up of 1¼-in. pipe. Steam is supplied direct from the boilers at a pressure of 100 lb. per sq. in. The air temperature in the room is kept at about 160 deg. F. Condensate is trapped back into the heating system return line.

What is the cost of the steam used for this purpose? We evaporate about 9¼ lb. of water per pound of coal and the cost of the coal is $10 per T. Operating expenses chargeable to this heating amount to about $24 a week.

M. D.

Strength of Boiler Parts

THE DIAMETER of a screwed weldless stay is ⅞ in.; what is the allowable pitch for a working pressure of 110 lb.?

2. The area of a segment of the head of a boiler drum is 714 sq. in.; how many 1⅛-in. diameter through stays would be required for a pressure of 100 lb., allowing a tensile stress on the brace of 7500 lb. per sq. in.?

3. If a flat boiler surface is provided with ¾-in. stay bolts spaced 4¾ in. what will be the safe working pres-

sure assuming a factor of safety of 7 and an ultimate tensile strength of 42,000 lb. for the bolts?

4. The diameter of a boiler shell, made of ½-in. plate having an ultimate tensile strength of 60,000 lb. is 60 in.; what should be the efficiency of the longitudinal joint to withstand a pressure of 150 lb., with a factor of safety of 5?

H. A. S.

ANSWERS

The minimum allowable pitch to withstand a pressure of 110 lb. with a staybolt ⅞ in. in diameter may be found from the equation

$$P = C \times T^2 \div p^2$$

where P is the allowable pressure, T, the thickness of plate in *sixteenths* of an inch, and p, the pitch. C, for plates less than $\frac{7}{16}$ in. thick, should be taken at about 112. For plates thicker than this, 120 may be used.

2. The total force to be held by stay rods to support 714 sq. in. of surface under a pressure of 100 lb. per sq. in. is $714 \times 100 = 71{,}400$ lb. If 1⅛ in. diameter braces are used, and if a stress of 7500 lb. is permitted, the total stress in each rod will be $0.7854 \times 1.125^2 \times 7500 = 7450$ lb. The number of through braces required will then be $71{,}400 \div 7450 = 9.6$ or say 10.

3. With ¾ in. staybolts placed 4¾ in. apart, where the ultimate tensile strength is 42,000 lb. and a factor of safety of 7 is used, the safe working pressure that may be employed, may be found from the relation

$$a \times T.S. \div F.S. = p \times A$$

where p is the safe working pressure and A is the pitch squared. Solving this equation for p, we find

$$p = 77 \text{ lb. per sq. in.}$$

4. The safe working pressure allowable on a boiler shell may be found from the equation

$$D \times p = 2t\, U_t\, E \div F.S.$$

where D is the diameter of the shell, p, the safe working pressure, t, the thickness of the plate, U_t, the ultimate tensile strength of the plate, E, the efficiency of the longitudinal joint and F.S., the factor of safety.

If D = 60 in., p = 150 lb., t = ½ in., U_t = 60,000 lb., F.S. = 5, then

$$60 \times 150 = 2 \times \tfrac{1}{2} \times 60{,}000 \times E \div 5.$$

transposing, $E = (60 \times 150 \times 5) \div (2 \times \frac{1}{2} \times 60{,}000) =$ 75 per cent efficiency.

Cooling Flue Gases

IT IS desired to cool the flue gases in a certain boiler installation from 650 deg. down to about 150 deg. F. by spraying water at a temperature of say 70 deg. F. in the path of the gases. To what temperature would this water be heated and what quantity would be required? In determining the quantity of flue gases to be handled assume 50 per cent excess air for burning Indiana coal containing 10 per cent ash and having a heating value of 11,500 B.t.u. per lb. We burn 2000 lb. per hr. J. M. S.

A. The coal you are burning is undoubtedly from Warwick Co., Ind., and has a typical analysis as follows:

Sulphur	4.8 per cent
Hydrogen	5.4 per cent
Carbon	62.3 per cent
Nitrogen	1.3 per cent
Oxygen	15.5 per cent

Theoretical air requirements for burning this fuel may be found from the equation

$$A = 11.5C + 34.2[H - (O \div 8)] + 4.3S$$

where C, H, O and S are the proportional parts respectively of carbon, hydrogen, oxygen and sulphur.

Substituting in this equation the figures taken from the analysis we find $A = (11.5 \times 0.623) + 34.2\,[0.054 - (0.154 \div 8)] + 4.3 \times 0.048 = 7.16 + 1.18 + 0.206 =$ 8.55 lb. of air per lb. of coal.

Using 50 per cent excess air you would have to supply $1.5 \times 8.55 = 12.8$ lb. of air per lb. of coal, as fired, and the products of combustion would amount to $12.8 + 1 =$ 13.8 lb. per lb. coal.

Reducing the flue gas temperature from 650 to 150 deg. F., or through a range of 500 deg. F., would mean an absorption (specific heat of flue gases, 0.25) of $500 \times 0.25 = 125$ B.t.u. per lb. of flue gas or $125 \times 13.8 = 1725$ B.t.u. per lb. of coal burned or $1725 \times 2000 =$ 3,450,000 B.t.u. per hr.

By spraying the water directly into the flue gases it will probably be possible to raise the temperature to within 5 deg. of the final gas temperature or to 145 deg. F. Inasmuch as the initial water temperature is 70 deg. the temperature rise will be $145 - 70 = 75$ deg. F. and the heat absorption will be 75 B.t.u. per lb. circulated. To absorb 3,450,000 B.t.u. per hr. you will have to circulate $3{,}450{,}000 \div 75 = 46{,}000$ lb. of water per hr. or about 92 g.p.m.

Applications of Ohm's Law

WHAT IS the combined resistance of those coils connected in parallel, if their separate resistances are 80, 8 and 16 ohms?

2. What is the combined resistance of these coils in series?

3. What size copper conductor should be used on a 230-v. circuit to transmit 100 amp. a distance of 400 ft. with an allowable voltage drop of 3 per cent?

N. P. N.

ANSWERS

The combined resistance of resistance elements connected in parallel is equal to the reciprocal of the sum of the reciprocals of the several units. Expressed mathematically

$$R = 1 \div [(1 \div R_1) + (1 \div R_2) + (1 \div R_3) + \ldots.]$$

Substituting the values given

$$R = 1 \div [(1 \div 80) + (1 \div 8) + (1 \div 16)]$$
$$= 1 \div (16 \div 80) = 5 \text{ ohms.}$$

2. In series the total resistance is the sum of the several resistances;

$$R = 80 + 8 + 16 = 104 \text{ ohms.}$$

3. Ohm's law states that the voltage drops along a conductor is equal to the current flowing, in amperes, times the total resistance of the conductor; that is,

$$E = IR.$$

If the allowable voltage drop is 3 per cent of the initial voltage, that is, 0.03×230 or 6.9 v. then

$$IR = 6.9$$

and

$$R = 6.9 \div 100 = 0.069 \text{ ohms.}$$

which is the maximum allowable resistance of 400 ft. of conductor. The wire to be used, then, must have a resistance not greater than $0.069 \times 1000 \div 400 = 0.1725$ ohms per 1000 ft. From a wire table we find that the size of conductor which has approximately this resistance is No. 2 B. & S. gage copper wire. As a matter of fact, this particular wire has a resistance of 0.1560 ohms per 1000 ft., hence the voltage drop over a length of 400 ft. would be less than 3 per cent or, more accurately, $3 \times 0.1560 \div 0.1725 = 2.7$ per cent.

POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

537 South Dearborn Street, Chicago.

Published by the Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879. Issued the 1st and 15th of each month. Established over 27 yr.

Subscription price $2.00 a year in the United States and all its possessions. Canada $2.75 a year. All foreign countries $3.50 a year.

Copies of current issue, 15 cents; of back issues, 25 cents.

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Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

New York Office, 150 Nassau St.
Circulation of this issue, 21,800.

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Our Demand for Service

Nothing is more characteristic of our modern civilization than the insistent demand for continuous service. In all the diversified phases of our daily lives we expect and demand service. If, when using the telephone, we are compelled to wait a few moments longer than the usual half minute or minute for the connection, we lose patience and, should the delay persist for, say, two minutes, we begin to deplore the utter lack of service. If the lighting service or the water supply is interrupted, we immediately choke up the arteries of communication to the public service company or the offices of the municipality, as the case may be, with demands for service.

It is because of this ceaseless demand for service that the parties responsible for its supply have come to regard the factor of reliability in a machine as of even greater importance than efficiency.

In a pumping plant supplying water to a large city, the requirements for continuous service are doubly rigid. The continued shutdown of such a plant would not only ruffle the patience and disturb the equanimity of 10,000 well-meaning souls but it might seriously endanger the health of the entire community served. Water is our cheapest but at the same time our most precious commodity and any interruption in its supply results in grave consequences.

It is natural, therefore, that when the engineers of the St. Louis Water Department were confronted some time ago with the problem of replacing all of the boilers in one of the largest pumping stations, they gave serious thought to the matter of maintaining continuous service while the changes were in progress.

Just how this work was accomplished forms the basis of an interesting story and its accomplishment is a fine example of practical engineering ingenuity. This story which appears in other pages of this issue should prove of interest to all engineers.

What Does It Mean?

Communism is defined in the dictionary as the "theory according to which private property should be abolished and all things held in common." This is a correct definition, as the whole elaborate theory of communism and socialism rests upon this simple premise. It does not sound dangerous or revolutionary. Yet this phrase of fifteen words contains all the potential elements of world conflict and ruin.

The Communist Manifesto was published in 1848. It stands today as it was written, and is the basic document in the platforms of all communist and political organizations of the United States and Europe. It is sometimes called the Ten Commandments of communism. The various secret organizations and political parties of the communist movement in the United States are governed by the mandate of this Communist Manifesto. The preamble and Declaration of Principles of the Socialist Party of America are predicated upon the rule of action laid down in it.

Aims of communism are plainly stated in the Communist Manifesto. The language is straight forward and conclusive, the six fundamental aims set forth in the Manifesto being: Abolition of, 1, ownership of private property; 2, all rights of inheritance; 3, the family; 4, marriage; 5, religion; 6, the distinction between town and country.

Shocking? Yes, to say the least. But that shock ought

to be hard enough and felt widely enough to make people realize the *truth*.

The language is plain enough. There is no mistake about it. Unfortunately, most of us who have given little thought and no study to the subject stop with that portion of the theory regarding private property. Few think further and this is why men fail to understand communism or socialism. They do not reason beyond the idea of community of property.

The dictionary definition mentions only one of the aims of communism, but this one really comprehends all the others, as all would realize if a little sound analysis was applied. The doctrine of community of ownership extends not only to property, but to the family, to marriage, to morals and to religion itself.

Knowing the six fundamental aims of communism, as set forth in Karl Marx's Manifesto, are you interested in learning more? Do you want the facts? Obviously they cannot be told in paragraphic editorials. The story would involve a series of several articles illustrated.

Now you may have those articles, printed in Power Plant Engineering, if you so desire. But before embarking on such a presentation, which is, to say the least, something of a departure from our former policies, the publishers of Power Plant Engineering want to know whether their readers desire it. This is your journal and we try to include only those things which will be helpful to you. If you would know the truth regarding Communism, its advance in America, its effect upon industry, and want to see it in the pages of Power Plant Engineering, write the Editor and tell him so. If sufficient letters request the insertion of this discussion to indicate a general interest, the articles will start in an early issue. Please let us have an expression of your wishes.

Off Duty

In just what manner, shape, or form, the announcement will be transmitted to the super-men and women living in the year 6924 A. D. we cannot venture to guess, but supposing that they still read newspapers, it is probable that it would read somewhat as follows:

"NOTICE! Focus in on Radiophotogram Station B 1993 XC at 7:35 o'clock tonight. Films of unusual historical interest will be broadcast. Motion pictures taken 5000 yr. ago show primitive state of civilization in 1924! Cumbersome methods for the generation of power and crude snail-like transportation facilities of that by-gone age faithfully portrayed. Don't miss this film. See the ridiculously crude and feeble attempts to generate electricity from water power. See the quaint customs and curious conventions of the people of those remote generations—their arrogance, their conceit, their simplicity of mind, their vanity. Study the fantastic architecture of that age and note the utter lack of standardization in everything, etc., etc. NOTE. This picture will be radiophotoed from the Radiophoto Central Theatre, 943rd St. and Broadway, New York City, but a limited number of seats are available at the theatre. Persons in Rio De Janeiro, San Francisco, Honolulu and other suburban points wishing to attend in person are requested to radiophone in their reservations not later than 6 p. m."

For the benefit of the reader who has not heard of the latest stunt in the motion picture world, let us explain that a number of motion picture films showing modern achievements are being sealed in special vaults in the Smithsonian Institute for preservation to posterity. These films which are given to the Institute by Watterson R. Rothacker will not be unsealed for at least 5000 yr.!

Until recently it was seriously doubted whether a motion picture film could be preserved for future generations. The oldest piece of film in the world was still young. What will a strip of film look like, five hundred, a thousand, five thousand years from now? That was the question.

In an endeavor to answer this question the Rothacker Film Mfg. Co. undertook a series of investigations in which rapid aging processes were worked out, and at the same time processes of preservation were investigated. Results of these experiments seem to indicate that (so the investigators claim) the film will last anywhere from 10,000 to 50,000 yr. So Mr. Rothacker, after all, is extremely conservative when he stipulates that the vault shall not be unsealed for at least 5000 years.

Shades of the Palaeozoic age! What next? Here we are calmly making motion pictures and putting a release date on them 5000 yr. in the future. What worries us, however, is this; how are we going to make sure that the instructions will be carried out? That is another problem. Unless human nature changes a lot during the next fifty centuries, the people living some 4900 years from now will be overwhelmed with curiosity to know what is in that mysterious looking vault. "Let's open the thing now," they will argue. "A hundred years from now we will all have 'kicked the bucket' and the wonderful knowledge which this vault contains will be lost to us. Come on, fellows, get a crowbar and open it up now. The old fogies who lived in 1924 won't know the difference."

In this way, Mr. Rothacker's purpose would be defeated. So, while we admire his foresight and generosity we do not think he has gone far enough, and we therefore, take it upon ourselves to make a suggestion.

We are in favor of putting a time lock on this vault so that no one can open it previous to the time specified. That solves the whole problem in a nutshell, so to speak, and Mr. Rothacker would be relieved of all further uncertainty. We could place his films in the vault, close the door, set the time lock for, say, 10:37 a. m. Tuesday, September 16, 6924, and after that rest assured that his instructions would be obeyed. Charlie Chaplin, Mary Pickford and Mabel Normand could be certain of having an appearance at that late date.

Imagine the sensation that a film of that nature would cause if released today! Next to it, King Tut's tomb would be a mere news item. Suppose, we could see movies of Babylon and Ninevah, or going back beyond the dawn of written history, suppose we could see motion pictures of the pre-glacial man, the cave man in his native haunts. What trains of thought such spectacles would incite!

Five thousand, ten thousand, fifty thousand years seem a vast stretch of time when viewed in the future, but what is it? A mere second in eternity. Whether man can intentionally and definitely write a history of himself which will be preserved throughout the ages is a question. A thousand, five thousand years—perhaps, yes. Fifty thousand, a hundred thousand, a million! No one can answer. Change is the law of the universe. Read the record of the rocks, they tell the story of the endless process of change better than anything else will. Under agencies which cause hard granite to be ground into fertile soil and which cause the same fertile soil to change into hard rock, can we expect a strip of motion picture film to endure? Time alone will tell.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Hotwell Pump Has Stuffing-Boxes Under Pressure

TO PREVENT air leakage into the pump through the stuffing-boxes, the Wheeler Condenser and Engineering Co. of Carter, N. J., has brought out a new hotwell pump which has the stuffing-boxes under pressure. In the usual design of two-stage condensate pump, the arrangement is such that the stuffing-box of the first-stage impeller is in communication with the atmosphere on one side, and is subject to the vacuum in the condenser on the other side. This difference of pressure is conducive to the leakage of air through the stuffing-box into the water which enters the first-stage impeller.

In the new Wheeler pump, the casting and impellers are so arranged that the passage from the condenser hotwell to the suction of the first-stage impeller is not in communication with the outside air through a stuffing-box.

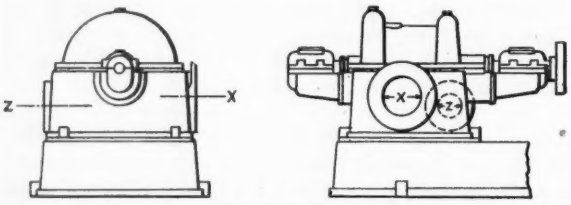


FIG. 1. SIDE AND END ELEVATIONS OF PUMP SHOWING SUCTION AND DISCHARGE OPENINGS

Instead, the stuffing-box, 1, of the first-stage impeller, 2, is under the pressure, due to the head generated by the first-stage impeller. In other words, the first-stage stuffing-box is located on the discharge side of the impeller instead of the suction side.

Referring to the three cuts, water from the condenser enters the suction opening "X" and passes through the suction passage to the suction opening of the first-stage impeller. The impeller is rotating and discharges the water in the volute chamber at an increased pressure which pressure is at least equal to, or greater than, atmospheric pressure. The water then passes through the intricate cored passage to the suction of the second stage impeller, 3. Impeller 3 is also rotating and discharges water through the volute chamber and out of the discharge opening "Z" against whatever external pressure the pump may be designed to operate.

Where the pump is designed to operate against a very considerable pressure, it may be advantageous to reduce the pressure on the high pressure stuffing box. To accomplish this, a labyrinth ring, 4, has grooves cut to mesh with corresponding grooves in the second-stage impeller, 3. Any water under pressure which leaks through this joint flows through the space next to this labyrinth ring and back through the equalizing pipe 5 to the region of lower pressure existing in the first stage volute chamber.

By means of this construction, the maximum pressure which can exist in the space next to the labyrinth ring and consequently in the high pressure stuffing box at the

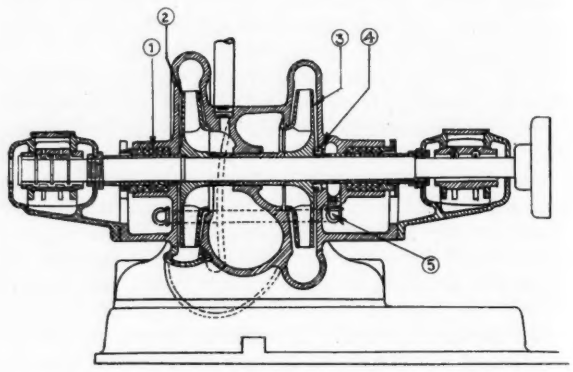


FIG. 2. LONGITUDINAL SECTION THROUGH WHEELER 2-STAGE PUMP

second stage end of the pump will be the same as that existing in the low pressure stuffing-box due to the pressure in the first volute chamber.

This pump is capable of pumping against a high total head, a feature which is of importance in many new installations, where the condensate on its way to the boiler is pumped through a number of stage heaters, causing a high head on the hotwell pump.

As may be noted, the casing is split horizontally, so that the impellers may be removed for inspection and repairs without dismantling the pump or disconnecting any of the piping. No sealing water whatsoever is required for the stuffing-boxes with this type of pump as the stuffing-boxes are under pressure with all conditions of operation.

Transmission Line Between Syracuse and Boston Opened Up

ONE OF THE longest high power transmission lines in the East has just been opened by which power connection is made between Boston and Syracuse, N. Y. The line carries 114,000 v.

Through an arrangement between the Adirondack Electric Light and Power Co. with the New England Power Co. and other power producing companies in New England power generated in New York State is now available in many parts of New England. This will be of especial value when the water supply or other agencies for producing power in New England drop below the required productivity. By the same means, power from New Eng-

land may be furnished New York State cities should similar conditions prevail there.

This new high power line starts from a station just outside the city limits of Syracuse and extends to a sub-station at Rotterdam Junction, N. Y., just outside the plant of the General Electric Co. at Schenectady. From this sub-station it can be distributed to various parts of New England by means of transmission lines.

With Boston now linked up with Syracuse, the time is not far distant when New England will be receiving power from Niagara Falls or other great electrical generating centers. If this is brought about and the current carried over lines now laid, Schenectady and Rotterdam Junction will become the most important power distributing center in the East.

Boston power is now linked up with many transmission lines extending into various parts of New England and in many instances where connection of transmission lines have not actually been made, completion of such connections is a matter of but small moment. Boston and nearby power companies already have a working arrangement whereby, in cases of emergency, power is made available from neighboring companies and in instances where storm conditions frequently affect transmission lines, exchange of current is a matter of frequent occurrence. The possibility of further development of power production at Spier Falls, near Glens Falls, N. Y., on the Hudson River, is being considered by those interested. In extreme emergency, too, the steam plant of the Adirondack Co. near Amsterdam, N. Y., could also be utilized without drawing upon water power sources.

Allis-Chalmers New Line of Pumps

ALLIS-CHALMERS Manufacturing Co., of Milwaukee, has recently put on the market a new line of centrifugal pumps for fire protection purposes. Centrifugal

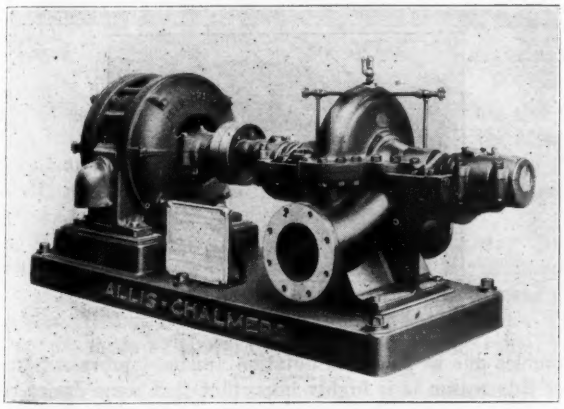


FIG. 1. 1000-G.P.M. SINGLE-STAGE FIRE PUMP DIRECT CONNECTED TO 100-HP. MOTOR

pumps have been used for fire protection purposes for some time and there are four sizes covered by the Underwriters specifications which are ordinarily sold. The capacities of these sizes are 500 g.p.m., 750 g.p.m., 1000 g.p.m., and 1500 g.p.m., respectively against 100 lb. pressure. These fire pumps were first of the multistage type to run at a speed of 1150 r.p.m.

Later the specifications were modified so that multistage pumps running at 1800 r.p.m. could be furnished, and the last change in the specifications now permits the use of single stage pumps. The Allis-Chalmers Co. has built for some years a special high head type of single-stage pump which has been used satisfactorily for heads as high as 300 ft. By making a few changes in the details of this pump, the company has been able to build them in accordance with the Underwriters Specifications and having

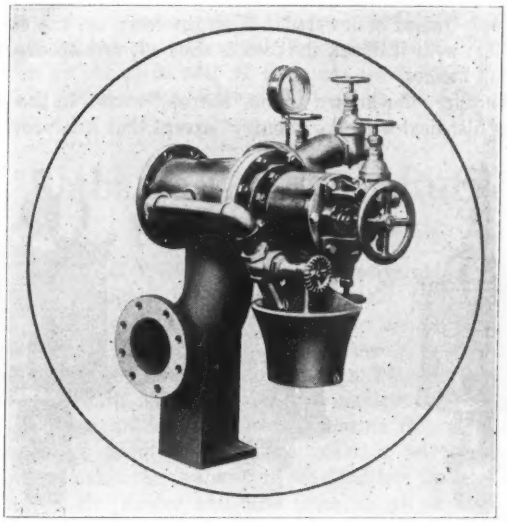


FIG. 2. 1000-G.P.M. UNDERWRITERS FIRE FITTINGS FOR PUMP SHOWN IN FIG. 1

characteristics acceptable to the Underwriters. This makes available an extremely simple type of equipment which is reliable and will give adequate protection.

Southern Power Company to Build New Plants

ANNOUNCEMENT OF THE construction of two new power plants involving an expenditure of some $5,000,000 was made recently by the Southern Power Co. The immediate construction program, includes a hydroelectric plant on the Catawba River and a steam plant at Duncan, near Spartanburg, S. C.

The capacity of the new hydro plant will be approximately 40,000 hp., which is about half of the capacity of the Mountain Island plant which recently went into commission. The new steam plant will be known as the Tiger power station and with a proposed capacity of 40,000 hp. will be one of the largest steam plants of the Southern Power Co.

Contracts for building the hydroelectric plant have been awarded to the Rhinehardt-Dennis Co., of Charlottesville, Va. Work is expected to begin as soon as the contractors can assemble their forces at Rhodhiss. It is expected that the plant will require about a year and a half to complete.

These announcements regarding new construction came immediately after the granting of the petition of the Southern Power Co. by the North Carolina Corporation Commission, for an increase in rates for hydroelectric power. These increased rates apply to users of industrial power but not to municipalities.

New Penberthy Oilers

IN THE ACCOMPANYING illustration are shown three new oiling devices which the Penberthy Injector Co., of Detroit, has recently placed on the market. The "Sentry" shown at the left is a sight feed, snap lever oiler with a spring hinged oil hole cover, adapted for use on engines, machinery or generator bearings. No amount of jar or motion will affect the working of their mechanism. When once adjusted for proper amount of oil feed, it requires no further attention. To stop or start feed, the lever is simply raised or lowered. With the lever up, the cup is feeding; with it down, the feed is shut off. At 45 degrees, the cup flushes.

Another oiler known as the "Satrap," shown in the center, is identical with the "Sentry" except that it is provided

NEW TYPES OF PENBERTHY OILERS

with a solid shank. The "Sancho," shown at the right, is made without the snap lever feature but is otherwise the same as the "Sentry" and the "Satrap." The hinged oil hole cover used on these oilers eliminates the possibility of careless attendants leaving the oil hole cover open, allowing dust and grit to mix with the oil.

New Lightning Arresters Afford High Protection

TO PROVIDE protection for lines carrying heavy currents, the Westinghouse Electric and Manufacturing Co. has recently developed a new large capacity, station type, lightning arrester for either indoor or outdoor service on a.c. light and power circuits. This arrester is known as the type SV Autovalve arrester. Although the Autovalve principle of lightning protection, around which this line of arresters was developed, is comparatively new, exhaustive tests have resulted in new standards of protection being set for both "discharge current" capacity and breakdown voltage values. These characteristics, combined with the fact that practically no attention is required to maintain the highest point of protective efficiency, make this line of arresters particularly suitable for automatic substation application.

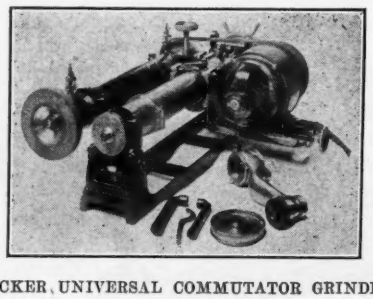
Their action depends upon the principle of the valve, as is indicated by its name. With normal conditions on the line, no current is passed and this condition exists until the voltage rises to a predetermined point where the gap breaks down, closing a low resistance path to ground. The discharge across the air gaps takes place in the form of a glow and the air in the gaps is the only active material. When the pressure drops below the value of the gap setting, the arrester circuit opens and the cycle of operation is complete. The performance is obviously that of a valve, for at a set value of excess pressure the valve opens, the abnormal energy is dissipated and then closes positively at a point slightly above normal pressure. The absence of any solid dielectric in the discharge path makes the operation of the arrester extremely rapid.

Simplicity of construction and ease of installation are among the distinctive features of the new arrester. Above 3 kv., all type SV arresters are assembled in three, "phase-to-ground" units with neutral points interconnected. Each unit is made up of a column of porcelain cases with spun metal ends in which four stacks of composition discs have been assembled with a thin mica washer between each disc and the completed assembly is such that the four stacks of discs are in parallel between the line which they are to protect and ground.

Up to 3 kv., the three-phase groups are built in a single stack, the outdoor type having an insulated steel covering. From 3 to 37 kv., the columns are formed by bolting each porcelain to the one below it without additional bracing. Above 37 kv. the columns are assembled in sections of five or six units and clamped together with wooden strain insulators, thus relieving the porcelain of any unusual stresses that might result from the long column. Four bolt holes in the bottom casting permit the mounting of the units quickly and easily on any suitable base, whether plate, channel iron, wood or concrete. The light weight and compactness of the units are factors which will find favor for such applications as require arrestors for platform mounting.

Decker Universal Commutator Grinder

AN INGENIOUS APPLICATION of the grinding process to the resurfacing of commutators is seen in the Decker Universal Grinder illustrated on this page. In the operation and maintenance of electrical equipment,



DECKER UNIVERSAL COMMUTATOR GRINDER

troubles due to poor commutation are most prevalent and for this reason it is highly important that some device be provided whereby the commutators may be kept in good condition. The Decker Universal Grinder has been developed with this end in view. The excellence of its mechanical design and its ready adaptability to all types of commutating electrical machinery make it highly suitable for central and sub-station maintenance.

As may be noted, it consists of a motor driven grinding wheel which is so mounted on a carriage as to permit of being moved horizontally along the commutator. The grinding wheel is driven through a belt and can be operated at 6000 ft. per min. against a commutator running at

normal speed. This speed secures a clean, true finish on the commutator.

Two wheels are provided with the machine, a coarse wheel for all first operations, and a fine wheel for finishing.

With this machine, it is claimed, commutators can be finished with such skill and accuracy as to secure a finish superior to that usually given to commutators on new generators or motors. The machine is manufactured and sold by the Shafer-Decker Co., of Rochester, N. Y.

Webster Patented Slit Grate Bar

SEVERAL FEATURES of interest are attached to the Webster Patented Slit Grate Bar, views of which are shown in the accompanying illustration. This bar is designed for the burning of low grade fuels with forced draft.

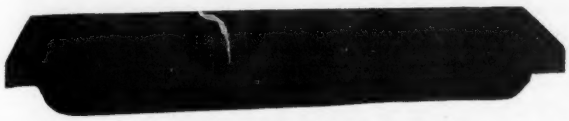


FIG. 1. THE WEBSTER SLIT GRATE BAR

As may be noted, the Webster grate bar is cast solid, and slits $\frac{1}{16}$ in. wide are cut across the face on a milling machine. These slits are spaced $1\frac{1}{4}$ in. apart, and give a 5 per cent air space, the same as provided by many pin hole grates and as is used on high grade stokers.

Air pressure is maintained under the grates (that is, in the ash pit) by a turbo blower and the slits in the bars control the air supply to the fuel bed. The slits provide the same amount of air for each square foot of fire.

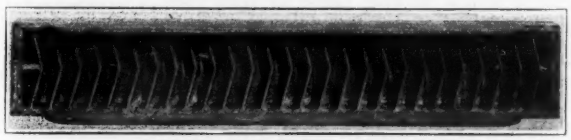


FIG. 2. AN UNDERSIDE VIEW OF THE WEBSTER GRATE BAR

It is claimed that the slit grates spray the air and do not lift the fuel bed. Their use make possible the attainment of a high CO_2 content in the flue gases due to the uniform and intimate mixture of air with the volatile gases of the fuel.

These bars are interchangeable with ordinary grate bars, and their installation will require only slight changes on the side brickwork and bearing bars in order to make the grates airtight for the higher draft pressure used. The bars are made by Howard J. Webster, of Philadelphia, Pa.

Work Started on New Fall River Plant

PRELIMINARY WORK has started on the construction of the big "super-power" plant at Fall River, Mass., which is being built jointly by three power companies supplying Southeastern Mass. The contract for the construction work has been let to Stone & Webster, Inc. Much of the site for the proposed group of buildings was covered with woodland. Part of this has already been cleared and the balance is being cleaned up. Work on the dock at Somerset will be started at once. Foundations for the office and storehouse of the plant are being put in place. Construction work on a large scale is expected to be started April 1. The company is known as the Montaup Electric Co., its charter and financing plans having been granted the approval of the Public Service Commission of Massachusetts.

It is planned to manufacture current at the new plant for distribution through the three companies now serving the territory which includes Fall River, Brockton, New Bedford and Taunton and other nearby points and which later will probably be extended into Rhode Island. It is believed that quantity production will result in a material lowering of the cost of current to the companies. The first section or complete unit of the new plant, with its connecting transmission lines, will cost in the vicinity of $5,000,000.

Alabama Co. Plans Rural Power Service

RESEARCH WORK of a comprehensive nature regarding methods of supplying electric power to the farmers of the South, is being contemplated by the Alabama Power Co. Definite arrangements between the Alabama Power Co. and the Alabama Polytechnic Institute at Auburn have been made to conduct this research. E. C. Easter, an engineer of the Alabama Polytechnic Institute, has been appointed to make a survey of the situation under the auspices of the Madison County Farm Bureau. Mr. Easter will first establish an experimental station on a farm where he will make a study of the economic uses of electrical power in ordinary farm work.

Under the agreement the Alabama Power Co. will build experimental lines in agricultural districts to determine just where the application of electricity to farm work will prove most feasible.

There are already 15 miles of power lines in rural service in Madison County, Alabama, from which several dozens of farms obtain light and power.

Adirondack Power and Light Corp. Starts New Plant

OPERATION OF THE new Spier Falls plant of the Adirondack Power and Light Corporation commenced on Jan. 21. This plant is one of five units which the company proposed to build. Otto Snyder general superintendent of the plant announced that 10,000 hp. were being generated at the present time but that when the plant is entirely completed, it will develop some 50,000 hp. The power is being fed to the Rotterdam distributing station. The single unit now completed has cost $70,000 but it is expected that more than a million dollars will be needed to complete the Spier Falls site.

Stephens-Adamson Mfg. Co. Builds Western Plant

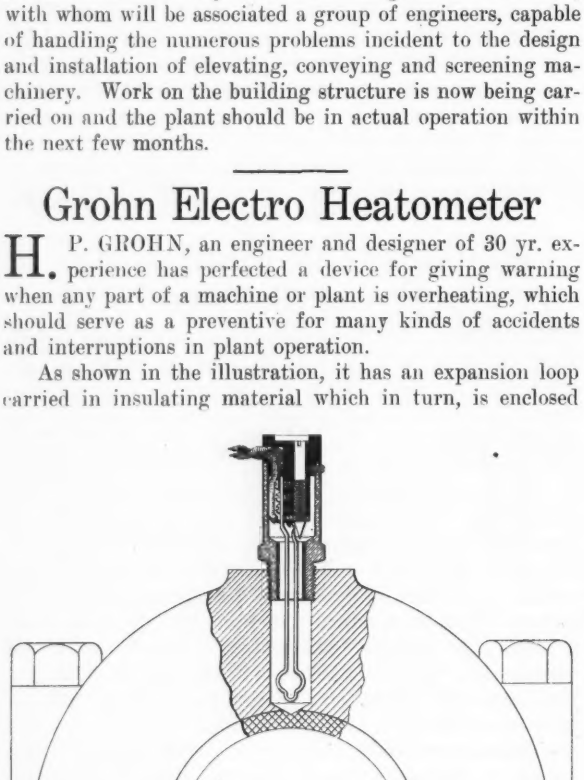
FOR THE PURPOSE of erecting a new branch factory and assembly plant, the Stephens-Adamson Mfg. Co., of Aurora, Ill., has recently purchased a tract of land in Los Angeles. During the past several years, this company has maintained sales engineering offices on the Pacific coast in order to handle the business available in the western states.

This new plant will fabricate and assemble material handling machinery for the industries in the western district. A staff of experienced designing engineers will be ready to serve customers in the preparation of designs for contemplated installations. This branch will also have erection engineers who will be available to assist in the erection and installation of machinery equipment. The Pacific branch factory will be in charge of R. C. Pierce, with whom will be associated a group of engineers, capable of handling the numerous problems incident to the design and installation of elevating, conveying and screening machinery. Work on the building structure is now being carried on and the plant should be in actual operation within the next few months.

Grohn Electro Heatometer

H. P. GROHN, an engineer and designer of 30 yr. experience has perfected a device for giving warning when any part of a machine or plant is overheating, which should serve as a preventive for many kinds of accidents and interruptions in plant operation.

As shown in the illustration, it has an expansion loop carried in insulating material which in turn, is enclosed



HEATOMETER WARNS AGAINST TEMPERATURE RISE

in a shell with ¾-in. pipe thread end. It can be screwed into any bearing, placed near the field of a dynamo or motor or installed so as to warn of increase in temperature of any room or material.

For a bearing, it should be so placed as to have the loop near the babbit of the bearing. For material such as a coal pile, it should be arranged so as to take on the temperature of the coal. For a room, it should be placed so as to act when the temperature rises at the point of greatest liability of trouble.

At the right is the screw for adjustment for temperature. To make an adjustment for a small range of temperature, the device is installed and allowed to come to the normal temperature of the location. The pin is then screwed down until it forms contact with the end of the expansion loop and rings the bell. It is then unscrewed until the bell ceases ringing and one-quarter turn further will allow for a rise of about 10 per cent before the signal will act. The signal may be a bell, an annunciator, or both.

Use of the double expansion loop is to get a greater range of travel so that the adjustment will be more sensitive. Greater range of rise before the signal acts is secured by allowing greater distance from the end of the loop to the screw. By the method of adjusting in place, a range of operation can be obtained from zero to 1800 deg., giving adaptability to any situation where it may be wanted.

Besides the uses mentioned, the device can be used for oil storage rooms, boiler plates, dry kilns, coal mines, cold storage rooms—in fact in any location and for any purpose where a rise in temperature will be likely to cause trouble.

The device is the product of H. P. Grohn & Sons, Chicago, Ill.

Teaching Economy in Combustion

NEW methods for feeding coal to boilers automatically, increased use of oil as a fuel for power boilers and efforts to utilize waste fuels for generating power have so broadened the field of the expert in combustion that the design and economical operation of furnaces and combustion apparatus has become a specialized branch of engineering. This brings the need for specialized training as was recognized by Joseph W. Hays when he crystallized into a course in combustion engineering the available knowledge on the subject.

How greatly the need of such a course was felt can be judged by the fact that such men as W. L. Abbott, Joseph Harrington, Fred R. Low, I. E. Moultrop, Arthur L. Rice, David Moffat Myers and Professor S. W. Parr consented to act as an advisory board to review the material and make suggestions in regard to the course and that they acted without any compensation, simply for the good of the industry.

As the course was built up, its proportions grew until it contained much allied knowledge of a broad educational nature which seemed essential to a proper grasp of the field of fuels and their uses. It has become, in fact, so extended that it seems to the Hays School of Combustion necessary to offer a shorter course for those who need training in the details of proper handling and combustion of fuels but do not wish to attempt the more extensive course in Combustion Engineering. Mr. Hays is, therefore, preparing a course designed for firemen and to be of a purely practical nature, while at the same time the more extended course will have features added to increase its effectiveness in teaching the theory and practice of combustion. This added expense will involve an increase in the price of the combustion engineering course.

The School had announced that this increase would take effect the first of February, but as it is now evident that the new practical course cannot be ready for distribution before the first of March, the old price on the engineering course will remain in effect until the later date.

Southern California Edison Co. Places Large Order for New Apparatus

ANOTHER STEP in the extension program of the Southern California Edison Co., with particular reference to the new steam generating station planned for Long Beach, Calif., has been the ordering of electrical equipment from the General Electric Co. totalling nearly $1,500,000 in value. This addition to the Long Beach plant will be built to create an additional steam reserve capacity.

Included among the equipment ordered are two 35,000-kw. turbo-generator sets, ten 13,000-kv.a., 73,000-v. trans-

formers; eight 73,000-v. lightning arresters; eight each potential and current transformers; twenty-eight 73,000-v. FK-39 48-YB oil circuit breakers, and four 3000-amp. H-209 oil circuit breakers. There are now no generating units of this size in the West and, should conditions remain unchanged until that time, these will be the largest steam turbo-generators ever shipped west of the Mississippi River. The new equipment will bring the available capacity at this station to a total of over 100,000 kw. With the installation of these units, the total rated capacity of the Southern California Edison Co.'s generating plants will be well over 400,000 hp.

Atlantic City Selected for 1924 N. E. L. A. Convention

FOLLOWING THE meeting of the National Executive Committee of the N. E. L. A. on December 14, announcement was made by President Walter H. Johnson that the 47th convention of the association will be held at Atlantic City, May 19 to 23 inclusive. The Exhibition Committee announces that an exhibit will be held in connection with the convention. This exhibit will be along the same general lines as the exhibit held in 1922, and the committee is now at work on the plans.

Ford and Detroit Edison Offer to Supply City with Power

REPORTS FROM Detroit indicate that both Henry Ford and the Detroit Edison Co. have offered to supply power to the city at a rate lower than the rate at which the city itself could produce power. The city has voted $12,000,000 to construct a power plant of its own. Alex Dow, president of the Detroit Edison Co., according to one report, has assured acting Mayor Martin of Detroit, that the Detroit Edison would be able to quote a price for power lower than that now paid by the city for power used to operate the street railways and street lights.

In order to be able to quote this price, the Detroit Edison Co., however, would have to have assurance that the city would not at some future date discontinue the use of power all at once, thus leaving the Edison Co. with a surplus which it could not dispose of.

Henry Ford has offered to supply power to the city from the new River Rouge power plant now under construction.

Pacific Power Companies Plan Extensive Development

IN THE enlargement of their production facilities, the extension of their services, and miscellaneous improvements of their utility properties, the two larger power companies in the state of Washington plan expenditures exceeding $6,000,000 in 1924. The Washington Water Power Co. will expend $2,000,000 on improvements and the Puget Sound Power and Light Co. upwards of $4,500,000.

An additional unit of the latter company's White River power plant will be built at once at a cost of more than $1,000,000. The plant will produce 23,000 hp. and should be in service by October or November of this year. On substation improvements and in building new transmission lines the company will expend $2,500,000 within the year.

The Washington Water Power Co. plans the construction of a new 110,000-v. transmission line from the company's Long Lake power station westward to a junction with existing lines at Stratford. A second unit of the company's power plant on the Similkameen River will be completed.

288,000-Hp. Plant for Los Angeles

LOS ANGELES Gas and Electric Corporation announce that work will soon be started on the construction of a new $12,000,000 steam generating plant at Seal Point. An eight-acre tract of land has been purchased on the east side of Alamitas bay inlet. A total of 288,000 hp. will be generated at this plant, which, when completed will be the largest steam power plant in the West. The $12,000,000 expenditure will include transmission lines.

News Notes

H. W. BROOKS has been appointed fuel engineer in the Department of the Interior, with headquarters at the Bureau of Mines experiment station at Pittsburgh, Pa. Mr. Brooks will head the section on efficient use of fuels. He brings to the work, besides a general training, the point of view of the constructing and operating engineer interested in public service plants.

OWEN D. YOUNG, chairman of the board of directors of the General Electric Co. and recently selected as a member from the United States of the reparations committee to help balance the German budget and stabilize the mark, sailed for Europe from New York, December 29. Two Americans were invited to serve, the other being General Charles G. Dawes, former director of the United States budget.

THE SANFORD RILEY STOKER CO., Worcester, Mass., announces that it no longer has any interest, financial or otherwise in the Ground Coal Engineering Corporation or its successor, Universal Engineers, Inc. Sanford Riley Stoker Co. will continue in the pulverized coal business on its own account and will announce from time to time the apparatus that it will manufacture and sell.

DAVID DALY, formerly District Manager of the Middle West group of companies under Stone & Webster executive management, has been selected as President of the Blackstone Valley Gas and Electric Co. which supplies electric light, power and gas service to Pawtucket, Woonsocket and other cities in the Blackstone Valley district of Rhode Island. Samuel B. Tuell, formerly Manager of the Houghton County (Mich.) Electric Light Co. and Houghton County Traction Co., succeeds Mr. Daly as District Manager of the Middle West Stone & Webster companies. The group includes the Mississippi River Power Co., Keokuk (Iowa) Electric Co., Fort Madison (Iowa) Electric Co., Paducah (Ky.) Electric Co., Houghton County Electric Light Co. and Houghton County Traction Co. Walter H. Burke, formerly Manager of the Keokuk Electric Co. has been appointed Manager of the Houghton County Electric Light Co. and Houghton County Traction Co. and Walter M. Bird, formerly Manager of the Fort Madison Electric Co. becomes Manager of the Keokuk Electric Co. while Mr. Bird is succeeded as Manager of the Fort Madison Electric Co. by Philip M. Wentworth, formerly Assistant Manager of the Truckee River Power Co., of Reno, Nev.

S. S. HOWELL has returned to consulting engineering practice on power, mechanical and electrical projects with offices at 608 So. Dearborn St., Chicago.

JOHN J. NOELL, formerly of the Electrical Company of Delaware at Wilmington, Delaware, is now in the Division of Construction and Engineering of Stone & Webster, Inc., Boston, Mass., as engineer in the Electrical Division, B. Morris Hooper, formerly engineer on industrial plant design and on appraisal work with H. M. Haven & A. T. Hopkins, Inc., of Boston, is now engineer in the Mechanical Division of Stone & Webster, Inc., of Boston.

MCCLELLAN & JUNKERSFIELD, INC., announces the removal of its home office to 68 Trinity Place, New York, N. Y.

ORDERS RECEIVED by the General Electric Co. for the year ending Dec. 31, 1923, amounted to $304,199,746, compared to a total of $242,739,527 for the year 1922, or a gain of 25 per cent., according to a recent announcement by Gerard Swope, president of that concern. For the fourth quarter of 1923, orders totalled $74,452,442, as compared with a total of $66,568,333 for the corresponding quarter in the year 1922, or a gain of 12 per cent.

TO CONFORM with its established plan throughout the United States, the General Electric Co. has created a Southwestern District to handle its apparatus business in Texas, Oklahoma, southern New Mexico and southeastern Arizona. The Southwest General Electric Co., as such, will continue to act as distributing jobber in the southwestern district. C. W. Hobson has been appointed Southwestern Manager in general charge of General Electric business in that territory, and L. T. Blaisdell, district manager.

THE GEORGE T. TRUNDLE, JR., Engineering Co., Cleveland, has just announced the organization of a new department to be devoted to problems of power and fuel. Demands of clients for special service in this field have made necessary this important addition to the company's services. The department is in charge of Prof. F. H. Vose, head of the Department of Mechanical Engineering at the Case School of Applied Science. During the war Prof. Vose was a consultant with the Fuel Administration, helping to straighten out power difficulties in the coal fields in Southern Illinois. In this new department with the Trundle company he will give particular attention to problems of power and fuel in manufacturing plants.

MCCLAVE-BROOKS CO., Scranton, Pa., announces the following changes in its sales organization. The branch office in St. Paul, which has heretofore been under the supervision of the Chicago branch office, will become the Northwestern District Office. The northern half of Wisconsin and the northern peninsula of Michigan will be included in the territory of this office. L. A. Picha will be the St. Paul Manager. J. C. Sanders, who has been in charge of the Southern territory for the past two years, will become Manager of the Western District Office at Chicago. A. J. Frett will continue as Assistant Manager of the Chicago office. B. L. Sanders will assume the managership of the Southern District Office at Greenville, S. C.

Sales in the State of Kentucky will now come under the jurisdiction of the Southwestern District Office at Memphis, where D. G. Counts is Manager. E. G. Whitmore, formerly in charge of the Engineering and Designing Departments in the McClave-Brooks plant at Scranton, will become District Sales Manager of the Scranton territory, comprising all of Northeastern Pennsylvania. C. A. Warg will succeed Mr. Whitmore as Manager of the Engineering and Designing Departments.

QUAKER CITY RUBBER CO. announces the removal of all departments of its organization to its factory at Wissinoming in Philadelphia, Pa.

THE NATIONAL Regulator Co. announces the removal of its general offices and manufacturing plant to its new building, 2301 Knox Ave., Chicago, Ill.

HAROLD F. MARSHALL has been appointed advertising manager for Warren Webster & Co., of Camden, N. J. He was until recently advertising manager for Dwight P. Robinson & Co., Inc.

GRAVER CORPORATION, East Chicago, Ind., has appointed L. H. Welling manager of its Eastern Office. Mr. Welling, who has been handling Graver products for several years, will have his headquarters at the New York Office, Grand Central Terminal Bldg.

THE STANDARD TURBINE Corporation, Scio, N. Y., announces the opening of its San Francisco Office, the representatives in that city being Halloran and Golcher. They also announce the opening of an Omaha Office, the representatives being the Industrial Sales and Engineering Co., a firm long established and with broad experience in power plant sales and engineering.

THE GIRTANNER ENGINEERING Corporation, of New York City, announces that the Lew Sales Co., of Rochester, N. Y., has been appointed district representative for Northern New York. This firm has had extensive experience in the handling of pipe line conveyors in the past and is capable of giving efficient service and attention to prospective business of this type.

C. H. DAVIES, for a good many years in the employ of S. F. Bowser & Co., has assumed charge of the Factory Sales Promotion Division of the entire Bowser organization, with headquarters in Fort Wayne.

Mr. Davies relieves L. E. Porter, Assistant General Manager, of this branch of promotional work, and now works in collaboration with T. D. Kingsley, General Sales Manager of S. F. Bowser & Co.

S. S. HOWELL, who, for the past 9 yr. has been identified as engineer in chief, with the United Chemical & Organic Products Co. and the Central Chemical Co., both of Hammond, Ind., will resume his private work as consulting engineer with office in Chicago. He is retained as advisory engineer to the above companies. He will give particular attention to the development of ideas and methods involving special application of engineering experience.

IMPORTANT CHANGES in the official roster of one of the International Combustion Engineering Corporation's Subsidiaries were announced recently: Joseph V. Santry, former vice-president of the American Sales Co., was elected president, succeeding George E. Learnard, who becomes chairman. The object of the change, it was stated, is to allow Mr. Learnard more time to take care of increasing activities of the parent concern.

John Van Brunt, chief engineer for the past 10 yr., was made vice-president in general charge of engineering. Carl

S. Reed, of the General Equipment Co., and Harlow D. Savage, were also elected vice-president. George P. Jackson was made chief engineer.

THE PERMUTIT CO., of New York City, has opened a new branch office at 250 W. Lafayette Blvd., Detroit, Mich. The new office will be under the management of Benjamin Saffe.

ROBERT H. BARCLAY, formerly electrical engineer with Starrett & Van Vleck, of New York City, is now engineer in the Electrical Division of Stone & Webster, Inc., Boston, Mass.

CHAS. A. BUTLER, New York representative for the J. E. Lonergan Co., of Philadelphia, Pa., has opened an office at 203 Park Row Bldg., New York City. The Lonergan Line will be on display at all times.

LAWRENCE D. KINGSLAND, 2D., formerly with The Foundation Co. as Superintendent of Construction of the filtration gallery for the new water supply at Lima, Peru, is now engineer in the Hydraulic Division of Stone & Webster, Inc., Boston.

ERNEST E. LEE CO., 115 S. Dearborn St., Chicago, and H. W. Jarrett, 5005 Euclid Ave., Cleveland, O., have been appointed Chicago and Cleveland representatives, respectively, of the Bernitz Furnace Appliance Co., of Boston, Massachusetts.

THE GENERAL ELECTRIC line of oil filled instrument transformers is being redesigned to allow the use of the same type of coil and winding now used in the distribution type of transformer. The new design will also include the interchangeable bushing now used in General Electric oil switches, distribution transformers and lightning arresters.

ALL PROPERTY OF THE Lincoln County Power Co. of Wiscasset, Maine, which was placed in the hands of a receiver a year and a half ago, has been purchased by the Central Maine Power Co. for $200,000. The sale has the approval of the Supreme court of Maine, which authorized the auction at which the bid of the Central Maine Power Co. was the only bid made.

LATHROP AND TROTTER is the new firm name of the Cincinnati representatives of the Conveyors Corporation of America, Chicago, Ill., Jay C. Lathrop having associated with himself L. E. Trotter. The offices of the firm are 733 Union Trust Bldg., Cincinnati, Ohio. The new firm will handle the sale of American steam jet ash conveyors, American air tight doors, cast iron storage tanks, and other power plant equipment in Cincinnati and the surrounding territory.

CHARLES R. DOUGHERTY, for the past 3 yr. working in the financial interests of the General Electric Co. on the Pacific Coast, died Nov. 27 at his home in Pasadena, Calif., at the age of 51. Mr. Dougherty began his business career when 17 yr. of age with the Thomson-Houston Electric Co. in Philadelphia, in a clerical capacity. He later became cashier of the Philadelphia office and, in 1894, was made auditor of the Philadelphia district of the General Electric Co. In 1913 he was transferred to Schenectady as a general assistant to the comptroller of the company. In 1920 his failing health necessitated his going to California to live.

WALTER REEVES DAME, of Clinton, Mass., one of the organizers of the Vermont Power & Manufacturing Co. and an official of power companies in Vermont, Massachusetts and Florida, died at his home, Jan. 10, aged 63 yr.

JAMES RAYMOND HAMMOND, of Stone & Webster, Inc., died of pneumonia, Jan. 7, at his home in Cleveland, Ohio. He had just reached his forty-seventh birthday, and was District Manager of the Division of Construction and Engineering in charge of the Cleveland office.

JAMES F. CLEARY died at his home in Medford, Mass., on Jan. 20, of pneumonia. For the past 12 yr. he had been connected with the organization of Stone & Webster, Inc., of Boston, Mass., and at the time of his death was engineer in the Station Betterment Division.

THE MONTPELIER & BARRE Light & Power Co., of Montpelier, Vermont, one of the Charles H. Tenney & Co. corporations, has been given permission to increase capitalization by $450,000 through the issuance of bonds. The proceeds will be used for the purchase and installation of new boilers and equipment which will insure a supply of current during periods of drouth. In the past, part of the load had to be disconnected during periods of extreme dry weather.

CONSTRUCTION WORK will commence within a short time for a large storage dam on the Moose River, a tributary to the Kennebec River, below Brassau Lake, which will provide a greater water and power supply for the industries along the Kennebec River in Maine. Investigation into the possibilities of this hydroelectric development were commenced in 1921, when surveys were made covering the territory. Many of the industries co-operated in the work and will co-operate in the development to be undertaken. It is understood that preliminary work will begin almost immediately so that actual construction can be pushed forward rapidly as soon as frost is out of the ground.

Books and Catalogs

ELEMENTARY STEAM POWER ENGINEERING by Edgar McNaughton; 590 pages, size 6 by 9 in., cloth, New York, 1923.

This book, comprising a discussion of the fundamental principles underlying the design, construction and operation of steam power plant equipment, is the result of the author's experiences teaching steam engineering. Although, as the author states, the book was written primarily for engineering students of college grade, the needs of the plant operator have been kept in mind and the mathematical treatment has been kept at a minimum.

Differing somewhat from the usual presentation of information on such topics as are here treated, the author's scheme has been to present the practical side before the theoretical; i. e., a description of the apparatus precedes the theory of its design and operation.

In the first chapter, the relationship existing between various items of equipment ordinarily found in the steam power plant is discussed. The rest of the book divides itself naturally into two parts. The first deals with representative types of boilers and their auxiliaries and includes a discussion of properties of steam, fuels and combustion, feed-water treatment and boiler testing. The second treats the various types of prime movers, pumps and condensers.

Included in this section are discussions on valve setting, engine and turbine testing, and methods of cooling condenser circulating water.

The Welding Encyclopedia. Third Edition. By L. B. Mackenzie and H. S. Card; 6 by 9 in., 360 pp., with 600 illustrations, charts and tables; leather binding; Chicago, 1923.

As its name implies, this is a treatise on the theory and practice of welding processes, defining words and trade terms and phrases, with special discussion of the more important words and terms. In addition special chapters are devoted to the most important processes, such as oxy-acetylene, electric, arc, thermit and resistance welding, and the welding of boiler plates, piping, tanks and rail joints. Installation and care of apparatus and regulations of federal state and insurance bodies are given. A chapter is devoted to Heat Treatment of Steel; also a chapter to Training Operators, with a complete outline of lessons for instructors.

Diesel Engines, first edition, by Lacey H. Morrison. XIII+ 598 pages, illustrated, cloth binding; New York, 1923.

Opening Chapters cover the history and development of the internal combustion engine in general and the Diesel engine in particular. The Diesel cycle is explained in detail and several chapters are given over to the description of standard makes of this type of engine. Economic status of the Diesel engine is presented from the viewpoints of comparative costs with other prime movers, original cost, maintenance costs and fuel consumption. Much practical information is given on the subjects of engine installation, maintenance of bearings, fuel oils, indicating the Diesel engine, operating procedure and oil engine testing. Separate chapters are devoted to the timing and adjustment of admission and exhaust valves, also the adjustment and maintenance of fuel pumps, governors and air compressor systems. Descriptions are also given of the airless injection type of oil engine.

Argand high duty and low duty forced-draft blowers are described in a bulletin now being distributed by the McClave-Brooks Co., of Scranton, Pa. With this blower, a combined air and steam blast is used which is said to keep the clinker comparatively soft and porous so that the blast will pass uniformly through the entire fuel bed.

A new 24-page booklet on hand and stoker-fired turbine blowers has been prepared by the L. J. Wing Mfg. Co., of New York City. This publication will be of interest to all who have use for forced draft equipment. It contains considerable engineering data on the application of these blowers to hand-fired boilers, also going into considerable detail in discussing the application of these blowers to underfeed and chain grate stokers.

The Kidwell Two-Flow Ring-Circuit Water-Tube Boiler is the title of a book recently issued by the Kidwell Boiler Co. This book is devoted primarily to the statement of underlying principles of boiler design and operation and a description of the Kidwell two-flow ring-circuit boiler. Early chapters cover the general principles of design and the history of the water-tube type of boiler. Boiler ratings, overload capacity, circulation, water column connections, priming, feed water and the deposit of sediment are also discussed. A large section of this book is given over to the history of the ring-circuit type of boiler and a description of the Kidwell boiler. Numerous illustrations are presented which show the details of construction of the various component parts the boiler, method of baffling and various types of settings. Chimneys for water-tube boilers are covered in the closing chapter. The general subjects, which are discussed under this heading are: functions of a chimney, draft, draft losses and chimney proportions.

"A Type for Every Stoker Need" is the title of a new circular just received from the Sanford Riley Stoker Co. of Worcester, Mass.

In bulletin No. 30 issued by the Fess System Co., of San Francisco, Cal., the type of oil burner built by this organization is described.

Bulletin No. 96-I, issued by the Foxboro Co., Inc., of Foxboro, Mass., describes briefly, yet completely, their many different types of recording and controlling instruments.

Grant Gear Works of Boston, Mass., have issued their 1924 catalog and price list. In addition to the price list the booklet contains a considerable amount of general information on gears and gearing.

An advance bulletin announcing the new Uniflow mechanical stoker has just been received from the Uniflow Stoker Co. of Springfield, O. This stoker is full mechanical and automatic in its operation and is designed for boiler up to 200 hp.

Flexible Steel Lacing Co., of Chicago, has issued a new circular "M" in which is described the Flexco-Lok lamp guard. This guard is an effective protector for incandescent lamps, and is made of expanded steel, is reinforced and tinned.

Bulletin Q B-1 issued by the Combustion Engineering Corporation of New York, N. Y., describes the Quinn PGS Burner. The letters PGS represent Pressure-Gravity-Syphon and indicate the principle upon which the action of this oil burner is based. This is a burner of extreme simplicity which is particularly adapted to the oil burning requirements of refineries. It is applicable to all forms of stationary boilers.

Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has issued a 24-page booklet, entitled "A Material of Endless Possibilities," containing information about Micarta and the many uses to which it has been put, and indicating the possibilities for other applications. Some of the products for which Micarta is already used are bushings, cord terminals, discs, fan blades, gears, gaskets, handles, insulators, knobs, pinions, pulleys, radio panels, switchboards, telephone apparatus, and washers.

"Steam, Its Generation and Use," published by The Babcock & Wilcox Co., has recently appeared in its 36th edition. The present volume is larger than its predecessor due in part to the addition of chapters on economizers, mechanical stokers and pulverized coal. The chapter on economizers considers their adaptability, materials of construction, design and effects of corrosion. Mechanical stokers are classified into three general types and a summary is given as to their advantages over hand firing methods. Pulverized coal is considered from the viewpoint of preparation, firing methods and furnace design."